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FORESTRY AND FOREST PRODUCTS.

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But Lorde! so I was glad and wel begoon!
For over al, where I myn eyen caste,
Weren trees claad with levys that ay shal laste,
Eche in his kynde, with coloure fressh and grene
As emerawde, that joy was for to sene.

The bylder oke, and eke the hardy asshe,
The peler elme, the cofre unto careyne,
The box pipe tree, holme to whippes lasshe,
The saylynge firre, the cipresse deth to pleyne,
The sheter ewe, the aspe for shaftes pleyne,
The olyve of pes, and eke the drunken vyne,
The victor palme, the laurere, to, devyne.

CHAUCER.

TEAK TREE, ANAMALLAY FOREST.

FORESTRY

AND FOREST PRODUCTS

PRIZE ESSAYS OF THE EDINBURGH INTERNATIONAL FORESTRY EXHIBITION, 1884

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PREFACE.

It was determined, on the winding up of the affairs of the Edinburgh International Forestry Exhibition, in December 1884, to publish a selection of the Essays which were successful in competition for the prizes offered by the Executive Committee.

In order to make the collection of real and permanent value, the authors were requested (except in the case of Mr. J. Alexander, where distance rendered it impracticable) to revise their proofs, which they did in all cases once, and in some twice.

The author of each Essay is alone responsible for the facts and views he sets forth; the Editors have not attempted to reconcile discordances between the Essays, nor have they altered expressions of opinion. While this method has certain drawbacks, it is believed that the book will gain more by diversity than it will lose by want of unity.

The Introduction is intended to sketch the rise of the idea of a Forestry Exhibition, and to delineate the leading facts of its accomplishment. As it does not bear on the subject proper of the book, it has not been included in the Index.

An attempt at a natural sequence governs the arrangement of the Essays in the volume; and in some cases the titles have been slightly altered from those given in the table on pages xlii-xliv, in order to become descriptive of the actual subject of the Essay.

The Prize Essays which are not included in this collection are those which have, for various reasons, been withdrawn by their authors, or which have already been published by them.

The Editors have to acknowledge gratefully the assistance afforded them by Dr. Hugh Cleghorn and Mr. John Murray, and they are also indebted to Mr. F. N. Menzies and Mr. Dunn for material bearing on the Introduction.

J. R.
H. R. M.

GRANTON, EDINBURGH,
July 1885.

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INTRODUCTION.

THAT specialisation which in recent years has been manifesting itself in Science, Literature, and Art is being reflected in our great displays of industrial work and natural objects. The age of Universal Exhibitions, inaugurated by that of London in 1851, when the Prince Consort's "primary idea of fostering peace and goodwill among men" first found expression, is past; and it is now recognised as more important to encourage such specialising tendencies as contribute to the rapid advancement of a small group of allied industries, than to hold Exhibitions where more interests are represented in a more general, and consequently in a more limited and less instructive, manner.

The backward state of Forestry as a science in Great Britain has long been deplored. Considering the vast extent of native forest in India and the British Colonies, the absence of any means for training foresters scientifically in this country appears as strange as it is unfortunate. While it must be acknowledged that no amount of theoretical teaching will diminish the necessity for a thorough practical education, the advisability of providing a class of fully instructed foresters will be readily conceded, and it ought to be possible to do so without applying for aid to the Forest Schools of foreign countries.

At a meeting of the Scottish Arboricultural Society in the autumn of 1882, reference was made to the great importance and value of the Forestry Exhibits at the Universal Exhibition held in Paris four years previously, and it was suggested that if an International Exhibition of objects connected with Forestry could be held, not only would an impetus be given to the science of the woods, but funds might possibly be procured which might be applied for the establishment of a Forest School in Great Britain.

In the spring of 1883 a meeting was convened for the purpose of making preliminary arrangements for such an Exhibition. The Marquis of Lothian occupied the Chair, and letters were read from the Earl of Rosebery, Mr. Maclagan, M.P., Mr. T. R. Buchanan, M.P., Professor Maclagan, and others, cordially supporting the proposal. As the result of the discussion at this meeting, it was agreed, on the motion of the Convener (Mr. Robert Hutchison of Carlowrie), seconded by Professor Archer, to be expedient to hold during 1884 an International Exhibition of forest products and other objects of interest connected with Forestry, with the view of promoting the movement for establishing a national School of Forestry in Scotland, and of furthering and stimulating the improvement in the scientific management of woods in Scotland and the sister countries, which had been recently manifesting itself; and, on the motion of Dr. J. Croumbie Brown, seconded by Mr. M'Corquodale, the meeting pledged itself to give its hearty co-operation and patronage to the promotion of the scheme. A large Provisional Committee was accordingly appointed, consisting of the Marquis of Lothian, the Earl of Stair, Lord Arthur Cecil, Sir Lyon Playfair, M.P., Mr. T. R. Buchanan, M.P., Mr. Maclagan, M.P., and others; Mr. Hutchison and Mr. Patrick Neill Fraser were elected Honorary Secretaries, and Mr. W. K. Rose, advocate, Mr. James Junner, S.S.C., and Mr. John M'Laren, Jun., Acting Secretaries. At the same meeting a resolution was passed, on the motion of Mr. Methven, seconded by Mr. Dunn, to the effect that, for the purpose of insuring success, a guarantee fund be opened for subscriptions, the sum intimated by any gentleman to be only payable in the event of there being a deficit, and then *pro rata* amongst the guarantors in proportion to the amount each subscribed.

The Exhibition thus projected was the first great display of the kind ever held, although forest products had previously found a place in, amongst others, the great London Exhibition of 1862, and that of Paris in 1878; and on this account the year 1884 will long remain memorable in the history of Forestry.

At an early stage of the Committee's existence the importance of securing the co-operation of the Highland and Agricultural Society of Scotland was recognised, and a letter was addressed to the Directors of that body, requesting them, if favourable to the scheme, to name some of their number to join the provisional Forestry Committee, to aid in elaborating and perfecting the arrangements for the proposed Exhibition. This the Directors readily consented to do; and in addition to subscribing a handsome sum to the guarantee fund, they passed the following cordial resolution:—

> "The Highland and Agricultural Society of Scotland, as representing the nobility, landed proprietors, and all who are interested in the management of landed property in Scotland, have learned with much satisfaction that the state of Forestry in Britain is to be brought under the notice of Parliament. The Society was instituted in 1784, and incorporated by Royal Charter in 1787, and its exertions have for the greater part of a century been specially directed to the advancement of practical forestry, by means of prizes for essays and reports on the management and general treatment of woods and plantations. The Society has contributed largely, as a body and by its members, to the introduction of many valuable forest trees suitable to the climate and wants of the country. In 1871 the Society instituted a system of examinations in Forestry, and grants certificates to candidates of merit as exhibited in their Syllabus. The Society would therefore hail with pleasure the organisation of a system of forest education in Great Britain as a matter of the greatest importance for the instruction of the forest officers, as they deem it a question of vast importance to this country as well as her various colonies."

As the engagements of the Provisional Committee increased, weekly meetings[1] became essential for the despatch of business, and accordingly a small Executive Committee—consisting of Lord Provost Harrison, Sir James Gibson-Craig, Professor Archer, Mr. Robert Hutchison, Mr. F. N. Menzies, Dr. Cleghorn, Mr. William Skinner, Mr. John Murray, Mr. M. Dunn, Mr. J. Methven, Mr. J. D. Park, Mr. J. A. Wenley,[2] with the Marquis of Lothian as President—was appointed.[3]

The preliminary work was energetically prosecuted during the next few months by this Committee, when, suddenly, the proposal to hold an International Exhibition of Horticulture, Floriculture, and Forestry in London during 1884 became known. The possibility of holding this Exhibition had arisen, in the first instance, from the fact that towards the close of the

---

[1] These meetings were held every Wednesday, at 3 P.M., in the office of the Highland and Agricultural Society.

[2] Mr. C. J. Mackenzie joined the Executive at a later stage.

[3] Of this Committee Mr. Hutchison, Mr. Menzies, Dr. Cleghorn, and Mr. Skinner were elected Honorary Secretaries, Mr. Wenley, Honorary Treasurer, and Mr. George Cadell, late of the Indian Forest Department, was appointed Secretary.

Fisheries Exhibition there Her Majesty's Commissioners had intimated to the Executive that, provided the grounds used for that Exhibition were employed solely for the purpose of holding similar displays, they were willing to extend the existing agreement, which expired at the end of the current year (1883), for three years. This offer was accepted, and the subject for 1884 was selected as indicated. But by this time the Edinburgh Executive had received many promises of contributions from home exhibitors and from foreign countries, and arrangements were so far advanced that it would have been difficult for them to recede, while it was perfectly evident that with the powerful competition of a London rival, their scheme could hardly prove a success. It was accordingly resolved to endeavour to arrange for the postponement of the more recent project, and in this matter the services of Lord Lothian and Lord Provost Harrison were of the greatest value. The Lord Provost wrote on September 4, 1883, to Mr. Birkbeck, M.P., Chairman of the London Executive, pointing out that the arrangements of the Edinburgh Exhibition were well advanced, that it would be inadvisable for two similar displays to be held simultaneously, and requesting that, if possible, other arrangements should be made. Mr. Birkbeck replied promptly and courteously, recognising the peculiar bearings of the case, and stating that the London Executive had resolved to postpone their Exhibition for a year. With this important concession the Edinburgh Committee was left free to mature the necessary plans for the success of the project.

In the meantime, a programme and classification of exhibits had been prepared. It was issued in the beginning of September 1883, and was divided into nine classes, and a miscellaneous section intended to embrace all suitable articles not particularised in the other divisions. This classification, in its finally adjusted form, is given in Appendix I., p. xxxi.

Concise practical Essays on subjects connected with Forestry, as well as systematic collections of forest produce, with accompanying reports, were solicited by the Executive to be handed in before June 14, 1884, and for these, diplomas, medals, and, in some cases, money prizes, were awarded on the recommendation of competent jurors. This volume gives a selection of the prize contributions to this class, and it will be found to embrace many practical papers, which may be taken as an indication of the present condition of knowledge on the several subjects of which they treat. The list of subjects upon which Essays or Reports were desired, as circulated by the Committee, is as follows :—

1. On the Formation and Management of Forest Nurseries.
2. On the Formation and Management of Plantations in various Sites, Altitudes, and Exposures.
3. On the Present and Prospective Sources of the Timber Supplies of Great Britain, with Statistics of the various descriptions of Timber Imported during the past twenty-five years.
4. Report, with Specimens, of any Hard Wood likely to supply the place of Box Wood for Wood-engraving.
5. On the Afforesting of Mountains and other Waste Lands, with details of the method adopted and the results obtained. To be accompanied with Drawings, Photographs, or Models.
6. On the Effects of Forests on Humidity of Soil and Climate, from personal observations made by the Author in any Country or Locality.
7. On the Treatment of Coppice and the Utilisation of Branches and Fragments of Forest Produce, with the view of diminishing waste.
8. On the Growth and Management of Eucalyptus Plantations, and their Economic Uses.
9. On the best Method of preventing Erosion of River Banks, with Illustrations.
10. On the comparative advantages of the various Methods of producing and harvesting Cinchona Bark, with Specimens.
11. On the Ravages of Tree and Timber destroying Insects, with Specimens and Illustrations.
12. On the Ravages of Mollusks and other Marine Timber-destroying Animals (excluding Insects).
13. On the Destructive Influence on Wood of Fungi and other Plants.
14. On the best Method of Maintaining the Supply of Teak, as regards Price, Size, and Quality, together with the best Substitute for Shipbuilding purposes. *Special Prize of* £50 *offered by the Shipbuilders of Glasgow.*
15. On the Utilisation of Forest Produce in the Manufacture of Paper.
16. On the Culture of Trees on the Margin of Streams and Lochs in Scotland, with a view to the Preservation of the Banks and the Conservation of Fish. *Special Prize of* £10, 10*s. offered by J. B. Duncan, Esq., W.S.*
17. On the Preparation and Use of Wood-Pulp. *Special Prize of* £20 *offered by the Scottish Papermakers' Association.*

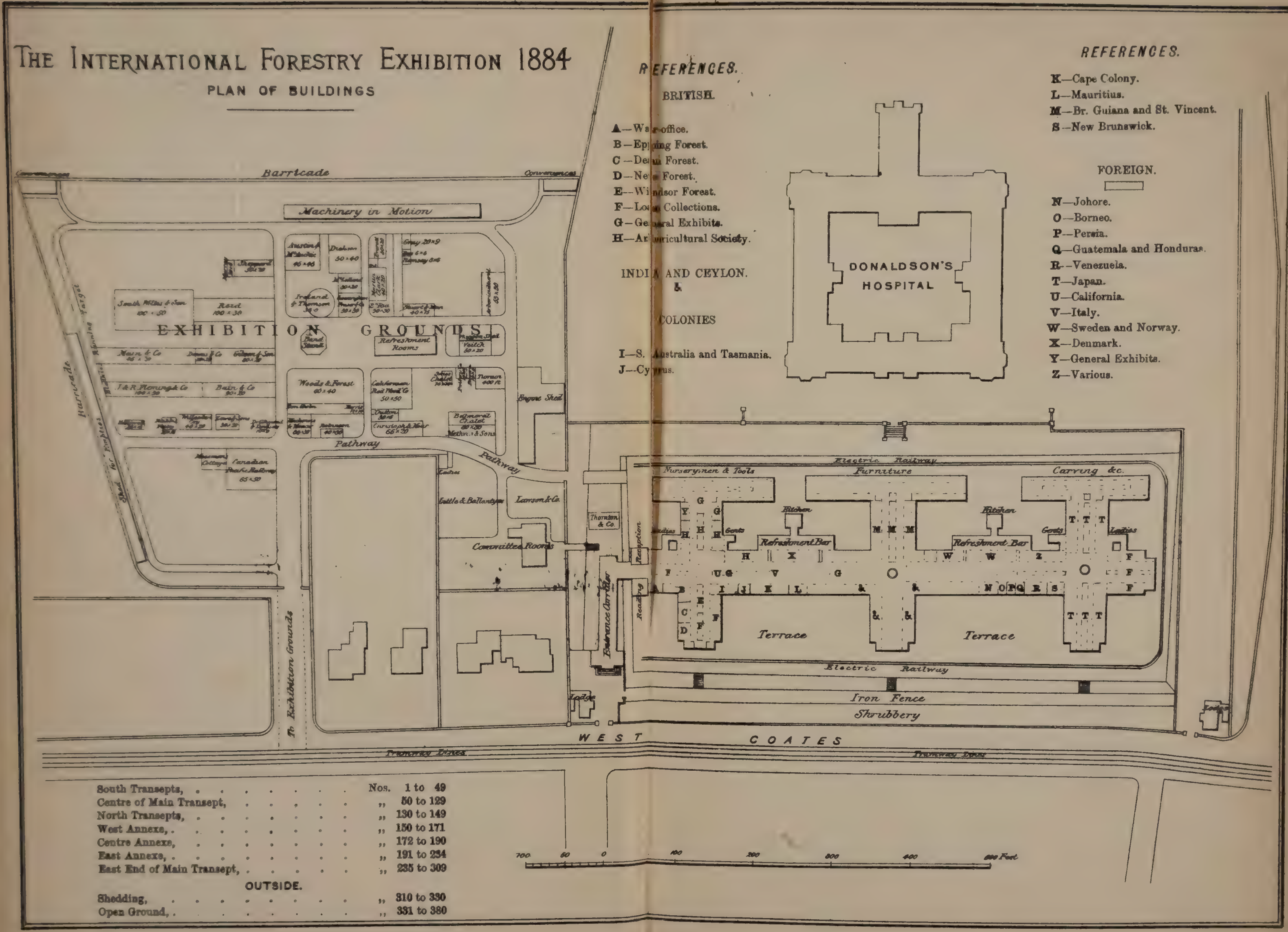
For an undertaking which was developing into one of great magnitude, and which was primarily intended to embrace all departments of forest work, and to illustrate all conditions in the manufacture and application of forest products, it was important that patronage of the most influential kind should be secured, hence the Executive received with feelings of great satisfaction the announcement that Her Majesty the Queen had consented to become a patron. The complete list of patrons comprises about 300 names, including those of a number of learned Societies, of many members of the British Royal Family, the Peerage, representatives of foreign Governments, the landed proprietors in Scotland, town-councils, and of other public bodies.

The General Committee of the Exhibition consisted of 177 gentlemen, and was under the presidency of the Marquis of Lothian.

Having issued their prospectus of classes for exhibits, the Executive empowered the Secretary to issue a code of regulations which they had prepared for the guidance of those who intended to forward contributions to the Exhibition. The twenty-four articles of this statement are given in full in Appendix II., p. xxxiv.

The guarantee fund, which had been started as soon as the scheme of the Exhibition was fairly launched, amounted by the end of July 1883 to £6095; but as it was desirable to make it considerably larger, a circular was addressed to the landed proprietors of the country and others, requesting subscriptions, and this appeal was backed by an advertisement in the newspapers, laying the matter before the general public. The fund was subscribed to by a large number of corporations and private persons—a complete list will be found in Appendix III., p. xxxvi—and finally the sum of £6899 was secured. With such a substantial reserve to fall back upon, the Committee could advance with confidence, and fortunately, notwithstanding the extensive scale on which all arrangements were made, and the smaller attendance of visitors than was anticipated, none of this fund required to be called up.

The question of a site for the Exhibition early came into prominence, and it was one by no means easy to answer. The requirements of sufficient extent, vicinity to the town, and easy access by road and rail, had to be considered, and the favourite position for the proposed buildings was, for some time, part of the West Princes Street Gardens. It was however found impossible to obtain this site, and the Meadows, the Queen's Park, the Calton Hill, the Arboretum



THE INTERNATIONAL FORESTRY EXHIBITION 1884

PLAN OF BUILDINGS

REFERENCES.

BRITISH.

A—War-office.
B—Epping Forest.
C—Dean Forest.
D—New Forest.
E—Windsor Forest.
F—Loan Collections.
G—General Exhibits.
H—Arboricultural Society.

INDIA AND CEYLON.
&

COLONIES

I—S. Australia and Tasmania.
J—Cyprus.

REFERENCES.

K—Cape Colony.
L—Mauritius.
M—Br. Guiana and St. Vincent.
S—New Brunswick.

FOREIGN.

N—Johore.
O—Borneo.
P—Persia.
Q—Guatemala and Honduras.
R—Venezuela.
T—Japan.
U—California.
V—Italy.
W—Sweden and Norway.
X—Denmark.
Y—General Exhibits.
Z—Various.

South Transepts,	Nos.	1 to 49
Centre of Main Transept,	,,	50 to 129
North Transepts,	,,	130 to 149
West Annexe,	,,	150 to 171
Centre Annexe,	,,	172 to 190
East Annexe,	,,	191 to 234
East End of Main Transept,	,,	235 to 309
OUTSIDE.		
Shedding,	,,	310 to 330
Open Ground,	,,	331 to 380

and Royal Botanic Garden, and the Waverley Market, all of which were proposed, were equally unsuitable, although each had certain advantages of its own. The site finally secured was the terraced slope in front of Donaldson's Hospital, and the adjoining ground to the west, the use of which was granted by the Heriot governors. This provided sufficient space, in one of the best parts of Edinburgh; it was within a short distance of two railway stations, and the tramway lines passed the door.

The plans for the Exhibition buildings, prepared by Mr. Robert Morham, City Architect, were accepted by the Committee in March 1884, and the execution of the design by the contractors, Messrs. Beattie and Company, gave entire satisfaction.

The building, when completed, was a wooden structure of good appearance, although the immediate neighbourhood of such a magnificent edifice as Donaldson's Hospital detracted considerably from the effect which it might have produced in less contrasted surroundings. The details of the central nave with its side-rooms and transepts are given in the accompanying plan. The western gate of Donaldson's Hospital formed the entrance, and a broad passage-way and short flight of steps laid in granolithic by Mr. Stuart, led to the turnstiles, from which a corridor 160 feet long and 25 feet wide, with various offices and waiting-rooms on one side, led inwards. A second corridor at right angles, on which the reception-room and jurors' room opened, gave access to the main hall, which was 630 feet long and 50 feet wide. Three transepts relieved the stiffness of the rectangular form, and those on the south communicated by short flights of steps with the lawn in front. On the northern side, the three annexes, 31 feet wide and 150, 200, and 150 feet long respectively, were connected with the transepts by covered passages. Large refreshment-rooms with fire-proof kitchens also opened off the north side of the nave. The iron framework of the roof was filled in with glass and patent felt roofing, its uniformity being broken by domes—the central one 77 feet, the others 70 feet high—placed over the intersections of the transepts with the nave. The central dome covered a handsome granolithic fountain, which was always well supplied with water. The walls, where not concealed by exhibits or pictures, were draped with dark maroon cloth, and the light blue couplings of the roof contrasted with these and with the brilliant displays of bunting in a very effective way.

The risk of fire in a building constructed entirely of wood, and filled with exhibits of a light and inflammable nature, was of course great, and the utmost care was taken to guard against any such accident. Members of the Edinburgh Fire Brigade were on duty day and night; abundant supplies of water were everywhere accessible, and smoking was strictly prohibited in the buildings. The precautions employed were found to be necessary and sufficient.

In order to make the Exhibition a success as an international display, it was necessary to secure the co-operation of Colonial and Foreign Governments; and by the exertions of the Marquis of Lothian the Colonial and Foreign Secretaries of the British Government were induced to take the matter up, and to send instructions to agents abroad. Lord Granville's circular, sent out by the Foreign Office in October 1883, is subjoined to show how thoroughly the Government appreciated the importance of the scheme :—

> "The attention of Her Majesty's Government has been directed to a project for an International Exhibition of Forestry to be held at Edinburgh in the summer of 1884, the organisers of which are desirous of securing the co-operation therein of such foreign powers as the matter may concern.
>
> "There is reason to believe that the proposed Exhibition, for which the necessary funds have been guaranteed, will be influentially and ably supported.
>
> "The object is one which, in the opinion of Her Majesty's Government, deserves every encouragement, Forestry having hitherto been much neglected in this country, and I have therefore to request that you will bring the Exhibition in question to the notice of the Government to which you are accredited, as being one in which their participation might be attended with advantages to both countries.
>
> "I enclose for communication to the proper quarters copies of programmes and other documents connected with the proposed Exhibition which have been supplied by the Committee.—I am, with great truth, your most obedient humble servant,
>
> "*For* EARL GRANVILLE, EDMOND FITZMAURICE."

Appeals from such powerful quarters were naturally not unavailing, and in many places—South Africa, Canada, and New Brunswick, for example—the local press interested itself in the matter, earnestly advising their respective Governments to spare no pains in contributing exhibits, as by so doing they would widen the ideas of the British and other European nations as to the timber-producing capabilities of their territories, and would probably give a stimulus to trade by introducing sample goods to the home markets. The representatives of the Governments of many foreign States and of the Colonies responded freely to the invitation and advice. Promises of contributions were received as early as August 1883 from Ceylon, California, and the Andaman Islands, while Jamaica, Canada, the United States, New South Wales, and the forest schools of France and Germany, early intimated their willingness to contribute. By the end of September the co-operation of Norway, Sweden, Cyprus, Greece, and Italy had been secured, and before the close of the year the support of the Government of Sierra Leone was obtained, and a duplicate collection of colonial woods promised by the Royal Gardens at Kew. In the beginning of 1884 the Maharajah of Johore intimated his complete collection; and South Australia, Gambia, British Guiana, Chili, Denmark, Mauritius, Tasmania, Honduras, and some of the United States, resolved to support the Exhibition. Afterwards, St. Vincent, Tobago, Siam, Florida, Venezuela, Borneo, San Salvador, Guatemala, Zanzibar, and New Zealand, came forward, and from that time on to the opening of the Exhibition new exhibits continued to be promised, and to arrive daily. It is true, indeed, that many countries were unrepresented, some even of those which had intimated contributions being prevented by unforeseen accidents from sending them, while others, by which further participation had been found impossible, sent official literature, maps, and surveys bearing on Forestry.

The reception and arrangement of the numerous public and private contributions, which, as might be expected, proved a task of great difficulty, were conducted successfully by Mr. W. E. Dixon and a large staff of assistants.

When the programme was originally drafted by the Executive, a scientific classification of the exhibits was deemed most desirable; but this was found impossible on account of the short time elapsing between the last date for receiving intimations of exhibits (April 1st) and the opening day (July 1st), the tardy arrival of consignments, the imperfect description of articles in the exhibitors' schedules, and the objections of many of the Commissioners to have their exhibits divided. A geographical arrangement was consequently adopted, the products of each nation being kept together.

Although it is impossible here to give an adequate idea of the extent and variety of the Exhibition, a short general sketch of the most prominent objects of interest may serve at least to recall to those who visited "The Forestry" their impressions at the time: it must necessarily partake too much of the nature of an imperfect catalogue to pretend to the dignity of a description.

The first objects seen in the nave on turning to the right at the main entrance were the specimens of woods employed at the Royal Arsenal, and stocks for weapons in various characteristic stages of manufacture, shown by the War Office. H.M. Commissioners of Woods and Forests filled the west side, and part of the centre of the western transept, with contributions from the Epping, Dean, New, and Windsor Forests; including tools, barks, sections of trees, and photographs illustrative of forestry operations and their results. The remainder of this division of the transept was occupied by loan collections; the object which attracted most attention being a section of *Sequoia sempervirens* thirteen feet in diameter. The tree from which this section was taken contained 6250 cubic feet of timber, and its age was estimated to be 2000 years. The specimens of home and Australian woods, carved wood-work, rustic ornaments, and illustrations of the diseases of trees, as well as many less important things, were dwarfed by comparison with this relic of a forest monarch. The exhibits from Cyprus, which included specimens of woods, resins, cones, and barks, were placed between the western and central transepts. The adjacent contributions from Cape Colony embraced a rich and varied assortment of woods, such as *Euclea pseudebenus* (Cape ebony), *Leucodendron argenteum* (silver-tree), *Rhus viminalis* (the karree-wood), remarkable for its flexibility, *Oreodaphne bullata* (stinkwood), named from its disagreeable smell, *Olea laurifolia* (ironwood), and many others. The Government of Mauritius contributed numerous specimens of woods valuable for economic purposes, and on account of their fine grain and susceptibility of high polish, and also a very extensive selection of fibres from indigenous plants, as well as a few samples of rubber.

Between this collection and the valuable and varied exhibits of India and Ceylon, which occupied the entire southern part of the central transept, and part of the nave, there were a number of interesting sporting trophies lent by the Queen, the Prince of Wales, and others. The Indian Department was so interesting in itself, and so admirably arranged, as to become one of the leading sources of attraction in the Exhibition, and one of the most valuable parts of it was the "Index Collection" of the Government of India, which consisted of over 800 specimens of gums, resins, dyes, tans, mordants, fibres and fibre-yielding plants, oils, seeds, perfumery, soaps, medicinal products, cocoons and silk, bamboos, cones, and samples of woods. The sections of trees from the Nilambur Teak Plantation in the Madras Presidency were of great interest and importance to foresters, a remarkable feature of these being the almost entire absence of the heart-shake. A very complete collection of dyes obtained from Indian vegetable products was sent by the India Office. The exhibits of the Indian Government were accompanied by a series of eighty-six books and reports bearing on Forestry. The Maharajah of Travancore supplied some forest-tree sections and a number of beautiful ivory carvings. The northern and southern circles of Bombay and Madras, Ajmere, Dehra Dun, Rangoon, and Moulmein, added valuable contributions; some of the bamboos (*Dendrocalamus Brandisii*) were especially remarkable on account of their enormous length, upwards of 85 feet. The collection of economic forest products from all parts of India was good and comprehensive, and as everything was carefully labelled, it was highly appreciated by those seeking information. In the arrangement of this important and extensive section Colonel Michael was assisted by the ready services of Dr. Hugh Cleghorn. From Ceylon the Exhibition received woods, gums, oils, insects, and birds, with specimens of the products of the cocoa-nut and palmyra palms, and of the various cinchona barks.

A valuable series of woods from New South Wales, which had been sent from the Royal Botanic Gardens, Kew, was shown on the east of the Indian court, and after passing the forest tree seeds from Vancouver Island, sent by the Government of British Columbia, the Canadian contributions appeared. Besides native woods of light colour and excellent texture, manufactured articles, implements for working timber, and photographs of forest scenes and products, were displayed.

It is a gratifying proof of the intelligence and scientific activity of the new and wonderful Western civilisation in the East that the entire space of the third transept was occupied by the extensive collections forwarded by the Japanese Government. It was unfortunate that, owing to delays in transit, these valuable and interesting exhibits did not arrive until after the opening day. They embraced machines and implements for practical forestry work, such as felling, transporting, preserving, and working up timber, a large assortment of wood samples, dried leaves, gums, resins, lacquer juices, drugs, fruits, edible fungi, as well as seeds, barks, and fibres. There were bamboos, ornamental woods, wood turnery, artistic work in wood and lacquer, wood-engravings, papers, collections of forest fauna and flora, and the like. A large chart illustrated the geological formations best adapted to the growth of trees in Japan. A mere list of these exhibits can suggest no idea of the ingenuity of the appliances, nor of the quaint mingling of the antique and modern in design, so characteristic of the Japanese art of to-day. In Japan the Forestry Department is an important State institution, with a head office in Tokio, and a branch in each of the forty-four *ken*, or counties into which the empire is divided. Within the last twenty years the Forestry laws have been so far consolidated as to be sufficient to insure efficient forest conservation. Three years ago a Forest School was established in Tokio—there is none as yet in Great Britain.

Passing the varied series of loan collections filling the eastern end of the nave, a stand occupied by specimens of native woods sent by the Government of Siam was to be seen, together with similar collections from Singapore, the Malay Peninsula, and Perak. On the north side of the main building the space between the central and eastern transepts was taken up by the Swedish and Norwegian exhibits. A large map illustrated the amount of forest in Norway, and the wood exports to Great Britain. Sawn and planed timber, mouldings, wood-pulp boards, and illustrations of the various stages in the manufacture of wood-pulp, which has recently become such a prominent feature of Scandinavian industry, formed the staple of these exhibits, but there were also plantation tools, specimens of forest trees, dried forest plants, and seed of pines and firs from various places, some spruce seed being shown from the confines of the Arctic circle.

Contrasting with the north European products on one side, and the east Asiatic exhibits opposite, British Guiana furnished one of the most valuable and interesting collections representing Tropical America. They filled the northern half of the central transept, and extended along the north side of the nave, presenting a bewildering profusion of wood specimens,—palms, fibres, medicinal barks, seeds, gums, dyes, and oils, with manufactured articles here and there,—canoes, hammocks, cocoa-nut cups, fans, and such things. The forest fauna was represented by sixty-eight specimens in spirit, by stuffed animals, and by the skins of armadilloes, ant-eaters, pumas, deer, tiger-cats, and alligators. A series of photographs showed more of the products of the country than could be conveniently sent in reality. The Governments of St. Vincent, of Tobago, and of New Zealand also sent contributions of wood sections and many other forest products.

In Denmark the Crown Forests are systematically managed by a large staff of foresters and assistants, and a Society has recently been started amongst the people, having for its end the planting of moors and waste land. Large and interesting contributions might be expected from this forest-conserving country, and they were received. Illustrations of the growth and culture of various trees, specimens of woods, instruments employed in the practical application of scientific forestry, in surveying and cultivating, and, as in the case of the other northern countries where the supply of pine wood is abundant, manufactured articles of all descriptions, and examples of wood-pulp processes were shown in profusion.

The Scottish Arboricultural Society, not content with starting and pressing forward the scheme for the Exhibition, contributed largely, the exhibits occupying the greater part of the northern division of the western transept and the adjoining walls of the nave. Meteorological instruments, dendrometers, tools used in forestry, models of bridges and river embankments, and specimens of woods were shown, and illustrations given of the durability of posts and sleepers in exposed situations. Cones of the rarer coniferæ, fungi, and insects injurious to trees, specimens of grafting, pruning, and other operations, paintings and photographs of trees, dried leaves, models of foresters' houses, rustic and more elaborately artistic wood-work, illustrated the wide range of subjects and sciences touched upon by forest work.

The extensive loan collection, participated in by about 150 exhibitors, which was placed at the disposal of the Committee, occupied most of the central tables in the nave. It formed a miscellaneous museum of woods, wood-work, and kindred subjects, full of natural-history objects,—birds, insects, plants,—beautiful carvings, models of ships, bridges, salmon-ladders, railways and buildings, and curiosities of many kinds.

In the three annexes many articles of great practical significance and economic value were presented,—machinery used in forest work and in the manufacture of wood products; manufactured goods, such as furniture of all descriptions, from the plainest to the most ornate; exquisite inlaid work; walking-sticks, fishing-rods, and indiarubber, native and manufactured. Some objects of more strictly scientific interest were also present, micro-photographs and microscopic specimens being specially noticeable.

Various parts of the Exhibition buildings, such as the entrance corridor, the committee and reading rooms, and other places, were enlivened by pictures, a collection of eighty having been lent to the Executive, who highly appreciated the kindness of the lenders. A small library, consisting of 129 volumes, bearing on Forestry, and contributed by a number of exhibitors, both at home and in foreign countries, was also displayed.

Outside the Exhibition buildings, in the adjoining field, a number of exhibits were arranged in sheds, and on the open ground. All of these were of an essentially practical nature.

The sheds were erected round the eastern and northern margins of the area, and contained gas and steam engines in action, horse hedge-cutting machines, and wood-working machinery of curious design, which produced work of the finest description before the visitors' eyes. Samples of wood and wire fencing were set out in one part of the field; and all over the ground summerhouses and conservatories were met with, built in every design, and of all materials, from paper to iron. By far the most elegant of these was the Scots pine châlet shown by the Queen; it was built at Balmoral of blown-down timber.

The model of a Manitoba farm, in which many interesting Canadian products were placed, was an object of general curiosity, and attracted crowds of sight-seers, anxious to see for themselves something of the nature of life in the great North-West. The foresters' houses, ornamental bridges, deer- and rabbit-proof fences of wood and iron, carts and rustic houses, were also examined with appreciation.

Perhaps the most attractive out-door displays were those afforded by the various nurserymen, who by means of their collections of new or rare coniferæ, hollies, and other ornamental shrubs, converted their section of the ground into a delightful garden.

In the middle of the open space a band-stand and refreshment-rooms were constructed for the amusement and convenience of visitors.

The Exhibition, whose rise and scope have been thus briefly sketched, was opened by the Marquis of Lothian, on Tuesday, 1st July 1884, at 1 P.M. Dr. Cameron Lees having commenced the proceedings with prayer, Lord Lothian, after explaining that at one time it had been expected that the late Duke of Albany would be present to perform the opening ceremony, referred to the origin of the Exhibition with the Scottish Arboricultural Society, and to the labours of the Committee. With reference to the aim of the Exhibition, he said: "All previous Exhibitions that have ever been held were different in character from this one. They were intended to show the result of man's ingenuity, and what human mind and art can do, but this Exhibition has not that so much for its primary object. It is rather intended to show Nature itself, and to try to teach those who come here how the first product of Nature—trees—may be fostered and preserved for the future benefit of man." He urged the desirability of holding conferences on subjects connected with Forestry, and expressed the hope that, as a result of the Exhibition, a School of Forestry might be established in Scotland. The Exhibition was then declared open, amidst the loud applause of a large and brilliant assembly.

Upwards of half a million people passed the turnstiles in the three months during which the Exhibition was open, and although at first the admission fee was so high as to make the attendance sometimes rather meagre, at a later date, when the exhibits had been got into proper order, a daily average of from 4000 to 5000 was attained. Every facility was offered for the convenience of visitors by season tickets, charged at different rates, according to the date of issue, and by special arrangements for the admission of large parties.

Many distinguished strangers favoured the Exhibition by their presence. First among these were the Prince and Princess of Wales, and their family, who, accompanied by the Earl of Rosebery and Lord Provost Harrison, were received by the Marquis of Lothian and other members of the Executive on August 22d, and examined with evident satisfaction many of the articles in the buildings and grounds. The Duke of Cambridge and Lord Northbrook came on the 28th, and next day Mr. Gladstone was received by a distinguished party, and excited the utmost enthusiasm amongst the visitors present. The Crown Princess of Germany and her daughters, attended by Count Seckendorff, paid a visit on September 12th, and Sir Stafford Northcote and party saw the Exhibition on that day, and on the 15th. Many other distinguished persons, including not a few of the representatives of Foreign and Colonial Governments, took opportunities to make themselves acquainted with the Exhibition.

As already implied, the Executive had made arrangements for the entertainment as well as for the instruction of their guests. The band-stands, both inside and outside the buildings, were regularly filled in the afternoons and evenings; the bands of the Midlothian Coast Artillery Volunteers, the Midlothian Rifle Volunteers, the Queen' Edinburgh Rifle

Volunteer Brigade, the City Police, the Scots Greys, and Royal Scots, frequently lent their aid, and the band of Her Majesty's Scots Guards and Mr. Simpson's Quadrille Band occasionally appeared. The music was always fully appreciated by visitors. On July 9th the Exhibition grounds were illuminated for the first time, and the display was frequently repeated under the management of Mr. Pain of London, who did much to add to the attractions of the place in the evenings by his skilful arrangement of Chinese lanterns and prismatic lamps. Another attractive feature was the electric light, which was supplied to the building, with the greatest success, by the Anglo-American Brush Company. More than fifty arc lights were first employed, and about 300 incandescent lamps were subsequently added. The dynamo-electric machines were driven by two of Robey and Co.'s engines, of 25 and 30 horse-power respectively. A short electric railway, which had been laid between the back of the Exhibition building and the front of Donaldson's Hospital, was run daily at short intervals. It was under the care of Mr. Binko, and was much patronised by visitors. Balloon ascents in the "Sunbeam" were made by Mr. William Dale, at intervals of a few days, in the latter part of August and during September.

With the view of extending the knowledge of the public on Forest questions, arrangements were made by which popular lectures should be delivered at intervals during the time the Exhibition lasted. The programme included the following subjects:—(1) Outlines of Forestry in Europe, by Dr. Lyons; (2) Wood, by Professor M'Nab; (3) Timber-destroying Molluscs, by Professor M'Intosh; (4) The Forests of New Brunswick, by Mr. E. Jack; (5) Eucalyptus, by Dr. Howitz; (6) The System of Forest Surveys in India, by Major Bailey; (7) Sporting Trophies, by Colonel Michael; (8) The Forests of Johore, by Mr. Meldrum; (9) The Management of Cumberland Plantations, by Mr. W. Baty.

For adjudication on the various classes of exhibits, as well as on the numerous essays that had been forwarded to the Exhibition, jurors[1] were appointed, who carried on their difficult and not always very agreeable work without remuneration of any kind, or even payment of expenses. Two members of Committee were appointed to attend the jurors of each class, and assist them by any information in their power, while taking no part in the adjudication.

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[1] For list of jurors, see Appendix IV., p. xl.

The jurors began their work on July 29th, and the list of awards, as finally adjusted, appeared on October 4th, 1884, one week before the close of the Exhibition. It is impracticable to reproduce this list here, but that of the awards for Essays will be found in the Appendix.[1]

Forests are of enormous importance to every country, and the absence of trees is a want of the gravest kind. In addition to supplying fuel, building material, and countless economic products, of value both in medicine and the arts, they tend to modify the climate and ameliorate drought by reducing evaporation from the ground, and to prevent sudden and dangerous floods, thus retarding denudation and sterilisation of land. Trees moderate the heat of summer and the cold of winter, by affording shade, and so diminishing radiation; and from the binding nature of their fibrous roots, they are important agents in fixing drifting sand, and in preventing erosion of river banks. Nor should the pleasurable effect of wood in a landscape be neglected, with all its variety from the freshness of the bursting buds in spring to the rich green foliage of summer, and the exquisite gradations of autumn tints. If then their functions from climatic, economic, and æsthetic standpoints be so significant, every means should surely be employed for the encouragement of forest growth, and the prevention of ruthless destruction of timber. The evils that have already overtaken Persia, Syria, Southern France, Cyprus, and other regions, and which are even now threatening what are yet important timber-producing territories, should suffice to enforce the necessity for adopting measures of conservancy in due time; and for this purpose every Government should see to the efficient training of a trustworthy staff of forest conservators. It need hardly be stated that this can best be done by the establishment of national Schools of Forestry. Since Dr. Cleghorn issued his

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[1] Appendix v., p. xlii.

Report in 1857, as Conservator of Forests in Madras, the value of such institutions has been referred to from time to time, but recently the question has been growing in urgency, and occupying a larger amount of public attention.

In August 1883, Sir John Lubbock, on the vote being taken for the Crown Woods and Forests, lamented in Parliament the absence of a British Forestry School; and recently the Highland and Agricultural Society of Scotland, and the Scottish Arboricultural Society, amongst others, warmly supported the scheme for the establishment of such an institution. It has been said, it is true, that Great Britain does not possess such a school, because no extensive Government *Forêts* or *Walder* exist, and because her abundant supply of coal renders the people independent of wood for fuel; but when it is remembered that the system of Forest Conservancy, as carried out in India, has proved an important source of revenue to the country, while at the same time insuring longer continuance, if not permanence, of the timber supply, and when it is also borne in mind that, according to authoritative report, upwards of 10,000,000 acres, which are at present of but nominal value, in Great Britain and Ireland, might, if put for a few years under trained conservators, become important sources of wealth, no doubts should exist in the public mind as to the advisability of establishing a Forest School.

The forests of Norway and Sweden, which not many years ago had so little monetary value as to justify their owners in burning them in order to procure a cereal crop from the soil enriched by their ashes, have now been placed under conservancy regulations with good results, while the immense, though diminishing, wood-producing tracts of America, formerly believed to be inexhaustible, are also being gradually subjected to similar supervision, since the necessity for so doing has become too imperative to be neglected. As Great Britain possesses in her dependencies a larger acreage of woodland than any other nation, it is obviously important to provide a staff of thoroughly trained practical foresters.

It is true that Forestry as an art has been practised for hundreds of years in all European countries, and for much longer in China and Japan, but as a science it may be regarded as dating from the first decade of the present century, when France and Germany gave an impetus to its study, which was carried on after some time with great vigour in Russia, Austria, Italy, and other European countries. In Britain, however, the question of the removal of the forests in India and America on too large a scale was not seriously considered till 1850, when, at the meeting of the British Association held at Edinburgh, a committee was appointed to consider the "probable effects, in an economical and physical point of view, of the destruction of tropical forests." In the following year this committee reported, and recommended the preservation and maintenance of indigenous forests, the institution of forest surveys, and the working of forests on well-devised plans. The discussion led to the establishment of the India Forest Administration by local governments in 1855, and for the whole empire in 1862. The system there is now organised, but the forest officers required for the Indian and Colonial forests are still trained in the forest schools of Germany or France.[1]

To Edinburgh is due the credit of first taking up the idea of a Forest School, and with a view to its establishment, the Town Council, some years ago, purchased the Arboretum at the Royal Botanic Garden for £20,000. Handsome donations have been received from various Governments and private exhibitors at the International Forestry Exhibition for the foundation of a Forestry Museum; and although, unfortunately, the proceeds of the Exhibition were not sufficient to secure the immediate establishment of a chair of Forestry, the people of Scotland, and of Great Britain and Ireland generally, only require to realise the importance and necessity of such a scheme in order to unite and carry it into effect; thereby removing the slight that at present attaches to our country in this respect.

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[1] A general account of the Forest Schools on the Continent will be found in *Forestry*, vol. xi., N.S., No. 18, October 1884, p. 452 *et seq.*

APPENDIX I.

CLASSIFICATION OF EXHIBITS.

CLASS I.—PRACTICAL FORESTRY.

Section 1. Implements and Tools used in Forestry. Draining, Enclosing, and Surveying Instruments, Chains, Dendrometers, etc.
" 2. Models of Foresters' Huts, Drying Sheds, Charcoal Kilns, Timber Slips, Sluices, Bridges, and Weirs.
" 3. Plans of River Embankments, Rafts, and Appliances for floating Timber.
" 4. Machinery or Models for transporting Timber and transplanting Trees.
" 5. Saw-mills, Wood-working Machinery of every description, and Pulping Apparatus, in motion or otherwise.
" 6. Fencing Materials of all kinds, including Gates and Stiles.

CLASS II.—FOREST PRODUCE, RAW AND MANUFACTURED.

Section 1. Collections of Timber Specimens and Ornamental Woods—(*a*) Indigenous or Naturalised, (*b*) Exotic.
" 2. Woods used for Ordnance—as Gun-carriages, etc.
" 3. Woods used for Railway purposes—Natural or Prepared.
" 4. Wood Pavements.
" 5. Cooperage—Tubs, Barrels, etc.
" 6. Wood-carving and Turnery, with Tools used.
" 7. Basket and Wicker Work.
" 8. Fancy Wood-work, including Veneers, Parquetery, Bog Oak articles, Stained and Coloured Woods, etc.
" 9. Wood Engraving, with Samples of Wood.
" 10. Bamboos—Canes, Reeds, and Manufactures therefrom.
" 11. Tanning Substances—Barks, Extracts, etc.
" 12. Dyeing Substances—Woods, Roots, Flowers, etc.

Section 13. Barks, including Cork.
„ 14. Fibres and Fibrous Substances.
„ 15. Materials for Paper Manufacture.
„ 16. Gums, Resins, and Gum Elastics.
„ 17. Wood Oils and Varnishes, including Lac of sorts.
„ 18. Drugs, Foods, Spices.
„ 19. Charcoal for Gunpowder, Tinder, etc.
„ 20. Peat and its Products.
„ 21. Cones, Seeds, and Fruits of Trees and Shrubs.

CLASS III.—SCIENTIFIC FORESTRY.

Section 1. Botanical Specimens of Forest Flora.
„ 2. Microscopic Sections of Woods.
„ 3. Parasites—Fungi and Lichens injurious to Trees.
„ 4. Edible Fungi—Natural or Preserved.
„ 5. Forest Fauna injurious to Woods.
„ 6. Forest Entomology.—Useful and Noxious Insects, with Specimens illustrative of damage done by the latter.
„ 7. Preservative Processes applied to Timber.
„ 8. Specimens and Diagrams illustrating the Geological Formations adapted to the Growth of Trees.
„ 9. Fossil Plants—Collections illustrative of the Trees of the Coal Measures, etc.
„ 10. Trees found in Bogs—Oak, Fir, etc.

CLASS IV.—ORNAMENTAL FORESTRY.

Section 1. Growing Specimens of Rare and Ornamental Trees and Shrubs—in tubs or otherwise.
„ 2. Rustic Work—Arbours, Bridges, Gates, Seats, etc.
„ 3. Dried Specimens of Ornamental Objects, including Foliage, etc.

CLASS V.—ILLUSTRATIONS OF FORESTRY.

Section 1. Paintings, Photographs, and Drawings of Remarkable or Historical Trees, Foliage, and Scenery.
„ 2. Delineations of Trees in their Native Countries, or of recent Introduction.
„ 3. Illustrations showing the Effects of Blight, Accident, Parasitic Growths, or any Abnormal Condition.
„ 4. Sketches of Practical Work and Operations in the Forest.

N.B.—*Special attention was invited to this Class.*

Class VI.—Forest Literature and History.

Section 1. Reports of Forest Schools or Departments—Forest Periodicals and other Publications—Manuals and Almanacs,—Treatises on Measuring and Valuing Woods, on Forest Floras of different Countries, on the Fixation of Dunes, and on Ancient and Extinct Forests.

„ 2. (*a*) Working Plans of Forests and Plantations, Valuations and Surveys of Estates, etc.

(*b*) Charts illustrative of the Geographical Distribution of Forest Trees, and their Altitude.

(*c*) Maps illustrating the distribution of Forest Produce, forming articles of British Commerce.

(*d*) Forest Book-keeping and Accounts.

N.B.—*Special attention was invited to Section* 2.

Class VII.—Essays and Reports.

Essays and Reports on Specific Subjects for which premiums are offered as per separate Schedule.

Class VIII.—Loan Collections.

Collections within the scope of the foregoing Classes—for example, illustrating the Fauna, Flora, or Forest produce of a province or district—would be accepted.

Class IX.—Economic Forestry.

Economic Conditions of Foresters and Woodmen.

Class X.—Miscellaneous.

Articles not particularised in the above Divisions, if bearing on the objects of the Exhibition, are admissible, with the sanction of the Executive Committee.

APPENDIX II.

REGULATIONS.

1. The Exhibition is intended to include everything connected with, or illustrative of, the Forest Products of the World, and will be open to Exhibitors from all Countries.

2. Entries close on 1st March 1884.[1] All Exhibits must be intimated by a Certificate of Entry, forms of which will be issued on application to the Secretary.

3. The Committee reserve power to restrict the space applied for, or to decline any application, in either of which cases the Secretary will, as soon as practicable, notify the same to the Applicant.

4. Exhibitors will be charged One Shilling per square foot of floor space. Open-air space free. Cases for Exhibits must not exceed ten feet in height.

> *N.B.*—A Committee was appointed to consider in *special cases* a reduction or remission of the above charge for space.

5. Exhibitors must pay all Expense of Transit, Delivery, Fixing, and Removing their Exhibits.

6. All Packages containing Articles intended for Exhibition must bear the distinctive mark, I. F. E., EDINBURGH, in red paint; and they must also have painted on them the Name and Number (which will be sent on allocation of space) of the Exhibitor. The Way-bill must accompany all Packages, and contain the name of the Exhibitor, his Number, and Address.

7. Arrangements will be made by the Committee for the reception of Exhibits, at a date to be afterwards fixed.

8. The Committee will not be liable for any loss or damage, from whatever cause, which Exhibits may sustain in transit, at the Exhibition, or otherwise.

9. Exhibitors must provide, either personally or by their Agent, for the reception, setting up, and removal of their Exhibits, and the verification of the same; in default whereof the Committee reserve the right of doing whatever they may consider necessary at the expense of the Exhibitor.

10. Exhibitors of Machinery requiring the use of Water, Gas, or Steam, must state, on making their entries, the quantity of Water, Gas, or Steam which will be required. Exhibitors of Machinery in

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[1] This date was afterwards changed to 1st April.

motion must state the rate of speed at which it is to be driven. The furnishing of all connections, shafting, pulleys, belting, etc., must be at the expense of the Exhibitor. Gas, Water, or Steam power will be supplied, on terms to be hereafter arranged by the Committee, and be under their entire control.

11. Medals, Money Prizes, and Diplomas for Exhibits and Essays, will be awarded by competent Jurors.

12. No Photographs, Copies, or any other reproductions of objects exhibited will be permitted to be taken without the consent of the Committee and the Exhibitor.

13. Contributors to the Loan Department are requested to communicate with the Secretary, who will supply special forms to be filled up by them. Free space will be given for Loan Collections and Workmen's approved Models.

14. No Exhibitor will be allowed to transfer any Allotment, or to allow any other than his own duly admitted Exhibit to be placed therein, except by permission of the Committee.

15. No Article can be removed before the close of the Exhibition, unless perishable, regarding which special arrangements will be made.

16. To insure uniformity of Decoration and general effect, no Exhibitor will be allowed to put up any Sign, Flag, Banner, or other kind of Decoration or Erection, without the approval of the Committee.

17. Exhibitors will be required to provide all necessary attendance, and to keep their Stands and Exhibits properly cleaned, and in good order, during the whole period of the Exhibition.

18. Exhibitors may mark the Selling Price of the articles exhibited complete, for the information of the Visitors and Jurors.

19. No Placards will be permitted either within the Exhibition or on the Enclosure except by special permission of the Committee. No Handbills, Newspapers, Books, etc., are allowed to be sold at the Exhibition without their sanction.

20. All Fulminating and Explosive Substances, and all dangerous materials, are absolutely forbidden to be sent.

21. All Cases must be Unpacked as soon as received, and the Empty Cases taken away by the Exhibitors or their Agents.

22. The Committee reserve the sole right of compiling and publishing a Catalogue of Exhibits, which can be purchased *only* within the Exhibition.

23. Smoking is strictly prohibited within the Exhibition Buildings.

24. All persons admitted to the Exhibition shall be subject to the rules and orders of the Committee.

APPENDIX III.

COMPLETE LIST OF GUARANTORS, IN THE ORDER OF THE AMOUNT OF THEIR SUBSCRIPTIONS.

The Marquis of Lothian.
The Town Council of the City of Edinburgh.
H.M. Commissioners of Woods and Forests.
The Highland and Agricultural Society of Scotland.
The Scottish Arboricultural Society.
The Surveyors' Institution, London.
His Grace the Duke of Buccleuch.
His Grace the Duke of Athole.
His Grace the Duke of Devonshire.
The Most Hon. Marquis of Bute.
The Right Hon. Earl of Seafield.
The Right Hon. Earl of Rosebery.
The Right Hon. Earl of Derby.
The Right Hon. Earl of Wemyss.
The Right Hon. Lord Tweedmouth.
Sir John Lubbock, Bart., M.P.
Sir Samuel Wilson, K.C.M.G.
W. Macdonald Macdonald, Esq., St. Martin's.
James Duncan, Esq., of Benmore.
J. C. Humphreys, Esq., London.
The Lord Provost and Corporation of the City of Glasgow.
The Right Hon. Earl of Selkirk.
His Grace the Duke of Westminster.
The Most Hon. Marquis of Tweeddale.
The Right Hon. Earl of Moray.
The Right Hon. Earl of Home.
The Right Hon. Earl of Haddington.
The Right Hon. Earl of Galloway.
The Right Hon. Earl of Northesk.
The Right Hon. Earl of Aberdeen.
The Right Hon. Earl of Fife.
The Right Hon. Earl of Breadalbane.
The Right Hon. Baroness Burdett-Coutts.
The Right Hon. Lord Lovat.
The Right Hon. Lord Vernon.
Sir J. W. Ramsden, M.P.
Lieut.-Colonel Farquharson.
Robert Jardine, Esq., M.P.
G. F. Barbour, Esq.
Colin J. Mackenzie, Esq.
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D. Christison, Esq.
C. Y. Michie, Esq.
D. J. Rodgers, Esq.
Hon. H. C. Maxwell-Stuart.

APPENDIX IV.

JURORS.

Dr. Aitken, Chemistry.
Prof. Archer, Science and Art.
Major Bailey, R.E.
Professor J. B. Balfour, Botany.
Robert Baxter, Forester.
A. W. Belfrage, Surveyor.
John Booth, Nurseryman.
Dr. J. Croumbie Brown, Forestry.
Professor Crum Brown, Chemistry.
Alexander Buchan.
J. Y. Buchanan, Chemistry.
Robert Bullen, Botany.
F. W. Burbidge, Botany.
J. A. Burrows, Estate Manager.
Sir James Campbell, Bart.
Major Campbell, R.A.
Sir Alexander Christison.
Charles W. Cowan, Paper Manufacturer.
Dr. Wm. Craig, Materia Medica.
Professor Dickson, Botany.
Colonel Dods.
Robert Douglas, Engineer.
Patrick Dudgeon, Mineralogy.
Professor Duns, Natural History.
W. E. Thistleton Dyer, Botany.
Colonel Charles Elliot, C.B., Forestry.
Professor Cossar Ewart, Natural History.
A. Fowler, Forestry.
C. S. France, Forestry.
P. Neill Fraser, Botany.
Professor T. R. Fraser, Materia Medica.
T. B. Fry, Forestry.
E. Fuchs, Forestry.
Robert Gray, Natural History.
Andrew T. Henderson, Engineer.
E. M. Holmes, Materia Medica.
Sir Joseph D. Hooker, Botany.
Edward Jack, C.E.
Robert Lindsay, Botany.
Dr. Lyons, M.P., Forestry.
W. M'Corquodale, Forester.
John M'Gregor, Forester.
Professor M'Intosh, Natural History.
D. F. M'Kenzie, Forestry.
John Ord Mackenzie, Forestry.
John M'Laren, Forestry.
A. A. M'Leod, Forestry.
Professor M'Nab, Botany.
H. Mainwaring, Forestry.
Sir H. Maxwell, Forestry.
W. H. Maxwell, Forestry.
James Meldrum, Forestry.
Sir Robert Menzies, Forestry.
John Michie, Forester.

Colonel Moncrieff, Ordnance Wood.
George Morgan, Saw-mill Engineer.
—— Paterson.
Lawrence Pullar, Dyer.
Daniel Scott, Forester.
A. Shuttleworth, Forestry.
F. Simmonds, Forestry.
R. S. Skirving, Entomology.
David A. Stevenson, C.E.
Andrew Taylor, Geology.
Professor Trail, Botany.
Dr. Traquair, Natural History.
R. G. Wardlaw Ramsay, Natural History.
Professor Wilson, Agriculture.
R. C. Wroughton, Forestry.

The following is the code of regulations which was drafted for the guidance of Jurors in their important and difficult work :—

(1.) At the first meeting of the Jury for each Class, the members will elect one of themselves as Chairman, who will direct the business of the Jury; one or more members of the Executive Committee shall attend on each Jury, and give such assistance as may be required.

(2.) The Chairman of each Jury, or in his absence the officiating Chairman, shall have the casting vote.

(3.) The place, day, and hour of meeting of each Jury will be fixed by the Chairman. The days of meeting will be posted in the Secretary's Office, and in the Jury Room, and the Secretary will issue notices of such meeting to each member of the Jury.

(4.) Each Jury may, if necessary, divide into sub-committees, but cannot come to a decision except by a majority of the whole Jury.

(5.) Each Jury may call in the assistance of an expert, specially acquainted with any object to be examined.

(6.) Exhibitors, who have accepted the office of Jurors, are thereby debarred from competing for awards in the class in which they act.

(7.) Exhibitors acting as experts will, for the same reason, be excluded from competition.

(8.) In the event of the prolonged absence of a Juror, the Executive Committee shall have the power of appointing one or more new members from Jurors in other classes.

(9.) A definite report must be submitted to the office of the Secretary, signed by the Jury, as soon as possible after the award.

(10.) The awards of each Jury must be confirmed by the Executive Committee.

(11.) The Executive Committee retain power to alter or amend the rules as they may find necessary.

APPENDIX V.

AWARDS FOR ESSAYS.

Essays included in this volume marked thus *

SUBJECT OF ESSAY.	AUTHOR'S NAME.	AWARD.
1. On the Formation and Management of Forest Nurseries.	*1. E. J. C. Brace, Les Vaux, Salbris, Loir et Cher, France.	Gold Medal.
	*2. Thomas Berwick, 56 North Street, St. Andrews.	Silver Medal.
2. On the Formation and Management of Plantations in various Sites, Altitudes, and Exposures.	*1. D. Cannon, Les Vaux, Salbris, Loir et Cher, France.	Gold Medal.
	*2. R. E. Hodson, Hollybrooke, Bray, County Wicklow, Ireland.	Silver Medal.
	*3. D. Stalker, Murthly Castle, Perthshire.	Bronze Medal.
	4. D. Tait, Owston Park, Doncaster.	Diploma.
	5. J. W. Inglis, Myrtle Bank, Trinity.	Diploma.
3. On the Present and Prospective Sources of the Timber supplies of Great Britain, with Statistics of the various descriptions of Timber imported during the past twenty-five years.	*1. Robert Carrick, Gefle, Sweden.	Silver Medal.
	2. D. L. Simmonds, 35 Queen Victoria St., London.	Bronze Medal.
4. Report, with Specimens, of any Hardwood likely to supply the place of Boxwood for Wood-engraving.	1. J. R. Jackson, Curator, Museum, Kew.	Silver Medal.
5. On the Afforesting of Mountains and other Waste Lands, with details of the method adopted, and the results obtained. To be accompanied with Drawings, Photographs, or Models.	*1. T. Milne, Glenburnie, Aberdeen.	Diploma.

SUBJECT OF ESSAY.	AUTHOR'S NAME.	AWARD.
7. On the Treatment of Coppice, and the Utilisation of Branches and Fragments of Forest Produce, with the view of diminishing waste.	*1. G. S. Boulger, 9 Norfolk Terrace, London.	Gold Medal.
	2. J. Fairley, 20 Ward Street, St. Rollox, Glasgow.	Bronze Medal.
8. On the Growth and Management of Eucalyptus Plantations, and their economic uses.	*1. E. J. C. Brace, Les Vaux, Salbris, Loir et Cher, France.	Silver Medal.
	2. D. L. Simmonds, 35 Queen Victoria St., London.	Bronze Medal.
9. On the best Method of preventing Erosion of River Banks, with Illustrations.	1. J. W. Inglis, Myrtle Bank, Trinity.	Diploma.
10. On the Comparative Advantages of the various Methods of producing and harvesting Cinchona Bark with Specimens.	*1. J. Alexander, Uda Pusalawa, Ceylon.	Bronze Medal.
11. On the Ravages of Tree and Timber destroying Insects, with Specimens and Illustrations.	*1. J. Alexander, Uda Pusalawa, Ceylon.	Bronze Medal.
13. On the best Method of maintaining the Supply of Teak, as regards Price, Size, and Quality, together with the best Substitute for Shipbuilding Purposes. (Special Prize of £50 offered by the Shipbuilders of Glasgow).	*1. W. T. Oldrieve, H.M. Office of Works, Edinburgh.	Special Prize.
	2. J. Nisbet, British Burmah.	Silver Medal.
	*3. J. C. Kemp, 86 Hill Street, Glasgow.	Silver Medal.
14. On the Utilisation of Forest Produce in the Manufacture of Paper.	*1. G. F. Green, 3 George Yard, Lombard St., London.	Silver Medal.
	2. D. L. Simmonds, 35 Queen Victoria St., London.	Bronze Medal.
15. On the Culture of Trees on the Margin of Streams and Lochs in Scotland, with a View to the Preservation of the Banks and the Conservation of Fish. (Special Prize of £10, 10s. offered by J. B. Duncan, Esq., W.S.)	*1. Rev. E. Maclean, Glen Urquhart, Inverness.	Half of Special Prize (£5, 5s.)

SUBJECT OF ESSAY.	AUTHOR'S NAME.	AWARD.
16. On the Preparation and Use of Wood-Pulp. (Special Prize of £20 offered by the Scottish Papermakers' Association.)	*1 { C. F. Cross, E. J. Bevan, Laboratory, 249½ High Holborn, London.	Special Prize.
	*2. W. J. Stonhill, Ludgate Circus, London.	Bronze Medal.
	*3. T. A. Reid, Fordbank Cottage, Runcorn, Cheshire.	Bronze Medal.
17. The Manufacture and Use of Charcoal.	*1. A. D. Webster, Llandegai, Bangor.	Diploma.
20. Forest Products of Malabar.	1. Rhodes Morgan, Malabar, India.	Bronze Medal.
21. On the Vegetation of Western Australia.	*1. Dr. A. Milne Robertson, 1 Alton Road, Roehampton, London.	Diploma.
22. Witnesses of Primeval Times.	1. Rev. E. Maclean, Glen Urquhart, Inverness.	Diploma.
23. On the Timber Trade of Kamrup, Assam.	1. A. J. Mein, Deputy-Conservator of Forests, Assam.	Diploma.
24. Lacquer (*Urushi*).	*1. Hikorokuro Yoshida, Japan.	Silver Medal.

I.

THE FORMATION AND MANAGEMENT OF FOREST-TREE NURSERIES.

By E. J. C. Brace, *Les Vaux, Salbris, Loir et Cher, France.*

There are very few branches of Horticulture on which at least three or four standard works by the ablest authorities of the day have not been published of recent years, and that at prices so low as to bring them within the reach of all. The science and practice of Forestry, however, has not been similarly favoured, and the most reliable works that have appeared are written in French and German, so that their contents can only benefit a few. In the important part of forest industry here considered, there is not in our language a single handbook, and only one French pamphlet,[1] by M. E. A. Carrière, treats exclusively of this subject. That, too, is intended more as a guide to the general nurseryman than to the practical forester. Dr. Brown, in *The Forester*, devotes to it a good deal of space, more or less diffused throughout the work, and M. Bagneris, in his *Elements of Sylviculture*, gives much simple, concise, and excellent counsel.

In the sequel it is proposed to deal only with essentially hardy forest subjects, excluding, so far as is possible, all purely ornamental and delicate kinds. The varieties cultivated in the forest nurseries of Sologne will accordingly be alone dealt with, as these are, owing to the extreme and variable nature of the climate, and comparative poverty of the soils, such as may safely be ventured on in the general operations of Forestry.

As in all other operations connected with this important industry, economy is, in the first instance, so far as it may be made consistent with good working, an absolute necessity, for even under the most favourable circumstances, the locked-up capital that has accumulated by the time the first thinnings are made must amount to a considerable sum; and although the subsequent returns are, under good management, both high and constant, the prime cost deters many proprietors from putting their lands under wood. Although a better knowledge of the principles on which Economic Forestry should be conducted are producing a revival in its favour, some years will probably yet elapse before its adoption becomes general, and the advantages resulting from it are fully realised.

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[1] Traité des Pépinières.

The first question to be dealt with is the selection of the site for a nursery, and in this matter some of the best authorities are at variance in their opinions. M. Bagneris recommends an eastern or south-eastern aspect, because the season of vegetation does not begin so early, and there is less danger of spring frosts. Dr. Brown, on the other hand, remarks that, with this exposure, the effects of the morning sun on the plants after a night's frost would be injurious. That this opinion is correct cannot be questioned; southern plants, which are tender in spring, being especially sensitive in this respect, although many so-called tender plants are capable of enduring many degrees of frost, provided they are thawed gradually. If therefore the sun has time to make its warmth felt previous to its striking directly on the seedlings, the danger of loss will be much reduced. In my own opinion, an aspect between south-east and south-west is to be preferred for general purposes. In the Sologne, for conifers, alders, birches, and other lovers of cool ground, a northern exposure is preferable, when it can be got, as the sun is usually strong from April to the middle of October, being especially powerful during the long periods of drought and heat that occur in July and August. In most parts of Great Britain the reverse is the case, and the more sunshine that can be brought to bear on the plants the better.

Apart from the question of aspect, the site of a nursery should be sheltered as far as possible on all sides, without being actually shaded, especially on those sides from which strong gales of any duration are to be apprehended, namely, the north-east and south-west. The shelter must not, however, be such as would impede a free circulation of air, without which a healthy condition of the soil and the plants cannot be maintained.

The following remarks of M. Bagneris[1] are so simple and to the point that they may be quoted at full length:—

"The ground must be slightly inclined, to avoid an excess of moisture, but not too much so, in order to escape the opposite extreme. . . . A nursery must not be placed in the midst of a lofty mass of forest, for, being shut up on every side, the air circulates there with difficulty, a circumstance favourable to frosts. Lastly, it is a great convenience during drought to have a spring or streamlet from which to water the seedlings.

"If the nursery is to be a permanent one, it should be made pretty large, as a single nursery is better than several small ones. . . . But it must not be so large as to render supervision difficult, and it is advisable not to let it exceed five acres."

M. Carrière prefers the site of a nursery to be perfectly flat, on the ground that it is more easily wrought; but a slight slope is a decided advantage, inasmuch as the lower ground is kept fresh by constant infiltration of moisture from above until comparatively late in the dry season, and all danger of stagnant water, the worst evil to which young plants can be exposed, is done away with.

With regard to extent, five acres is as much ground as is likely to be required, under ordinary circumstances, for the maintenance of a sufficient supply of the commoner kinds of forest trees up to two years of age. Abies and Piceas certainly require to be kept for another year or two; but the practice of putting out on a large scale unwieldy plants, twice transplanted, of four and five years of age, is rapidly losing ground, both on the score of economy and of the subsequent development of the trees. It can only be recommended in the case of specimen plants of the scarcer varieties, or where blanks have to be filled up; but these are not likely to be needed in any great quantities.

Under all circumstances the nursery should be well fenced in, more especially in those places where ground game is abundant, the damage that can be done by a single rabbit in the course of one night being very great. They may be kept out by galvanised wire netting with one and three-quarter inch mesh, and one metre (three feet four inches) in height. If the mesh is larger, young rabbits get through, and do quite as much harm as the old ones, and if it is lower they will often climb over it.

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[1] Elements of Sylviculture, p. 210.

The lower part is buried from four to six inches in the ground, and the supports are formed of iron rods one centimetre (two-fifths of an inch) thick.

It is always a good plan to surround the nursery with a ditch three feet wide at the top and two feet deep,[1] the wire netting being adjusted on the inner side of this, about six inches from the edge. The expense is not great when compared with the advantages gained, and the larger the area to be fenced in the less the cost. If well cared for, the netting will last for a number of years.

Where cattle only have to be kept out, strong galvanised spiked wire on wood or iron uprights may answer the purpose. A hawthorn, privet, or other hedge, certainly affords some shelter when it has had time to grow up, but as this is a matter of some years, and the protection derived is but slight, and its effect only felt for a distance of a few yards, its value lies more in its appearance than in its actual utility. Wood fencing is very neat, but very costly.

An excellent natural trellis is made by the close planting and intertwining of young plants of *Gleditschia triacanthus.* This is much used in Normandy, and other parts of France, and might be found of equal service at home. The seed is cheap, and the plant hardy, as well as of rapid growth; for strength and durability it will outlast any artificial fencing.

Roads and drains now demand attention. These should be marked, and made previous to the cultivation of the ground. In our nurseries, in all of which the outline is made to approach as nearly as possible that of a perfect rectangle, a main cart-road three metres wide runs down the centre, and another at right angles to this. A ditch similar to that surrounding the nursery should be made along one side, at any rate, of the former, and along the upper side of the latter. Many prefer square or circular depots for manure, etc., to be left at intervals along the course of these roads, but on the grounds of neatness and economy these should be outside of the boundary. It is more convenient to leave the tracing of the smaller paths until the ground has been dug.

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[1] In heavy wet soils a greater depth may be necessary.

A thorough system of drainage is of the greatest importance, as without this the healthy growth of the plants cannot be expected, and the action of the atmosphere upon the soil would be much impeded. In ordinary circumstances, the dimensions of the drains may be the same as that of those surrounding the nursery. Dr. Brown recommends, in *The Forester*,[1] that they should be made as deep as forty-eight inches, but, save on lands wholly unfitted for nursery operations, half this depth should suffice. Their frequency will depend upon the nature of the soil and the steepness of the slope: stiff soils require more numerous and deeper drains than light soils, but for nursery purposes the latter should always have the preference. Covered drains are expensive items, and should be avoided if possible. In our own nurseries, open drains answer all requirements, and they are much more economical. Drains running along the slope at sufficient intervals are quite as necessary as those running transversely to it, and the crossings only will require earthenware or concrete pipes.

Passing to the question of soil and its preparation, M. Bagneris says that, whatever the soil in which the seedlings are ultimately to be put out, the nursery should be situated in a deep soil of good quality. . . . Here they will be vigorous and well furnished with roots, and will therefore escape the risks that attend the operation of potting out better than others. The mineral composition of the soil is of minor importance, because it is modified by the mould or manure put into it. Nevertheless, *sandy loam is to be preferred.*

M. Carrière discusses the merits of rich and poor soils at some length, and reasons thus:—

"On rich lands the plants push with extreme vigour; the buds are plump, long, and well developed, the bark is smooth and even; in a word, the young trees seem to combine all the elements of success and prosperity. But if these plants on leaving the nursery are put out into bad or indifferent soils, as is often the case, they will . . . not die, but sustain a general loss of health, caused by the reaction, partly due to the sudden and great change from a rich soil to a poor one, and partly from the shock which invariably attends transplantation. One must not be surprised therefore, if these trees sulk, or make but poor growth during the first few years.

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[1] *The Forester*, chap. xii., p. 488, *et seq.*

"If, on the other hand, the trees are raised in an indifferent or poor soil, and encounter a course of vegetation entirely the reverse of the above, they show less growth, the buds are shorter and less developed, and the bark, instead of being smooth and even, is often rough, and sometimes covered with moss and lichens."

Generally, it may be said that the development of the roots will be in exact proportion to that of the upper parts of the plant, and that in the case of poor or badly cultivated soils the plants will be ill furnished with the former, on the presence of which the tree's future wholly depends.

A moderately rich, free, light soil of good hygroscopic power, inclining rather to poorness than otherwise, is that best suited for the raising of seedlings: and experience teaches that more depends upon a prolonged exposure to atmospheric influence, and a subsequent thorough preparation, than upon the relative proportion of the chemical constituents of the soil itself. Stiff clays are decidedly to be avoided, for the value of a nursery soil depends chiefly upon its hygroscopicity. Where, however, the clay bed underlies a good spit of sandy soil the ground may by judicious treatment be brought into a high state of fertility.

Moreover, for the first year or two of their growth, most plants will develop freely in soils that would prove utterly unsuited to them at a later period, and the subsequent change from a soil which was somewhat deficient in the essential elements to one well furnished with them, would be an advantage rather than otherwise, provided they were at the time of removal sufficiently furnished with fibrous roots to avail themselves of it, and to feel the shock of transplantation less keenly.

Only in a very few places, such, for instance, as parts of the Sologne, can one find within the limits of an ordinary nursery such variety of soils as to enable one to allot to each particular species the class of soil that seems to suit it best, and, generally speaking, this is by no means necessary.

Previous to the first sowing (save when land is first put under some other crop) the ground is not manured, but a top-dressing of decomposed leaf-mould, mixed with a certain proportion of quicklime or superphosphate, is dug in. After the first crop of seedlings the land should be kept constantly manured, so that the principal elements of fertility may be always present in abundance.

A certain amount of importance attaches itself to the colour of a soil. Dark soils, for example, are more subject to the action of extremes of heat and cold, owing to increased radiation, so that they are generally unsuited for tender seeds. When no other ground is available, the seeds should be sown later, and sheltered when they begin to come up. Usually in such cases the seat of injury is the tender young stem, close to its point of contact with the ground; and in the case of the hardier varieties, such as larch and spruce, it is due, not so much to the action of the frost, as to the subsequent effect of the sun's rays striking directly on the frozen surface.

As regards the subsoil, if this is hard and impenetrable it is sufficient in itself to render a site unfit for nursery purposes, as it prevents the escape of surplus water by infiltration.

"In such cases the subjacent watery stratum forms a kind of pond, in which the roots of the trees are constantly plunged."[1] This stops their development, and may cause them to decay.

The worst economy that can be practised in the formation of a forest nursery, and the probable, if not certain, precursor of failure, is to fail to give the utmost care and attention to the thorough preparation of the ground, as the vigorous upward growth of the young plants, and the extent to which they develop fibrous roots, depend far more on the fine state of division to which the soil has been reduced than on its richness in those chemical constituents which are so necessary in after life. Moreover, on this too depends the maintenance of a permanent supply of moisture by capillary attraction.

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[1] M. Carrière, *loc. cit.*

"Before sowing a nursery," says M. Bagneris, "the soil must be well cultivated, and that, too, deeply, in order to render it light; at the same time it must be freed from stones. But in turning up the soil care must be taken not to bring the subsoil to the surface. . . . Deep cultivation is justified by the fact that it admits air into the soil, causes the roots to develop rapidly, and, while permitting the infiltration of rain-water, opposes drought."

"The chief advantages," says the author in another place,[1] "to be gained by deep cultivation are these:—

"1. Stagnant water cannot lie within reach of the roots of the young plants, while a free supply of moisture is maintained by capillary attraction.

"2. A relatively higher earth-temperature is obtained even in the coldest months. Bottom heat is a very important aid in the process of germination. In tropical climates the temperature of the soil is nearly always in excess of that of the air; in temperate climates the reverse usually holds good.

"3. The action both of frost and of extreme heat is less felt on deeply dug lands, and penetrates to a less depth, while the moisture derived from the dew at night is absorbed more freelv and parted with less readily."

Such considerations show that the ground should be trenched thoroughly all over, to a depth of at least two spits, and care should be taken not to bring the bottom spit up to the surface, but the soil should be evenly mixed. If constant and careful attention is exercised in this work, there will be, when the ground has settled, fully eighteen inches of thoroughly prepared soil, a depth sufficient for all general purposes. Many advocate a depth of two feet, but this involves a considerable addition to the expense without much practical gain. Trenching should be carried out during the months of November, December, and January; and the surface should be

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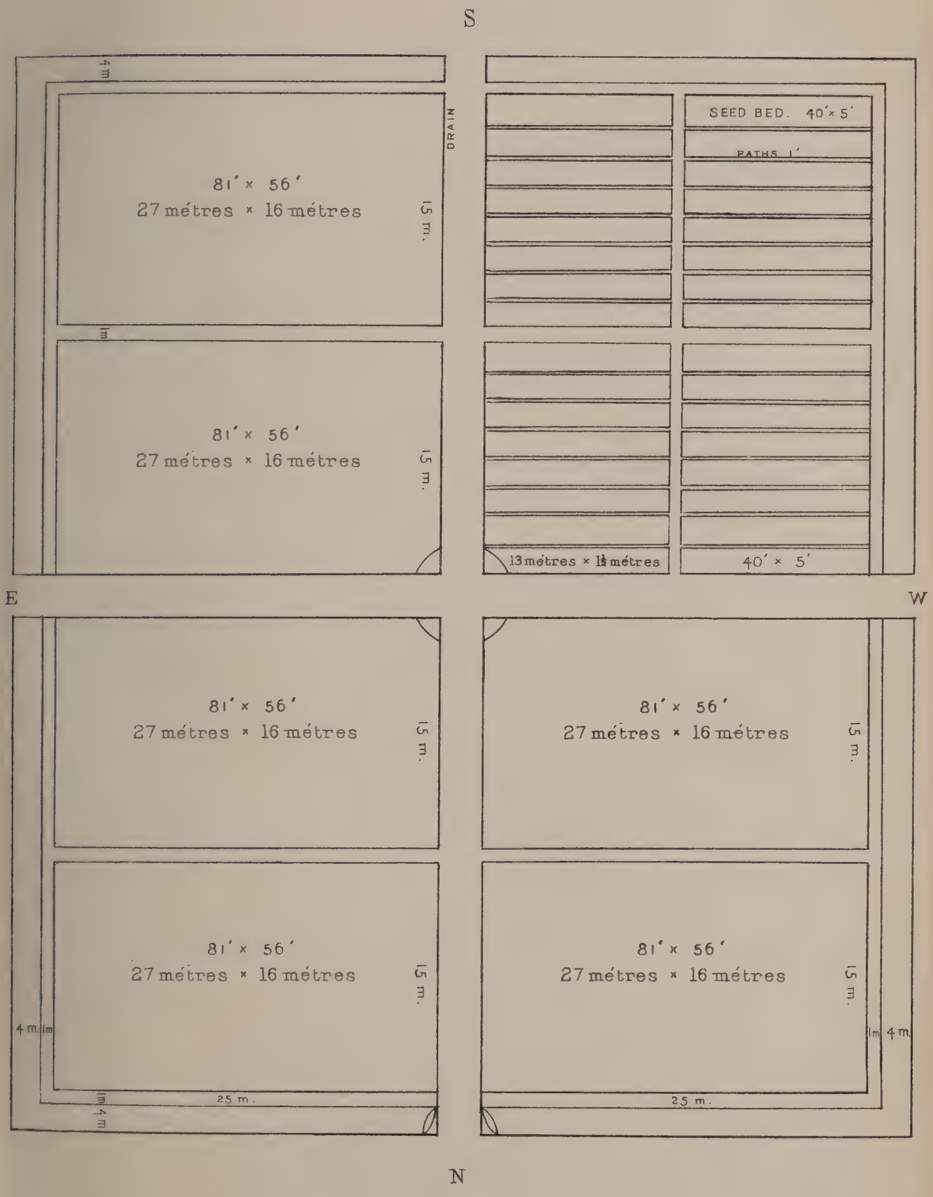
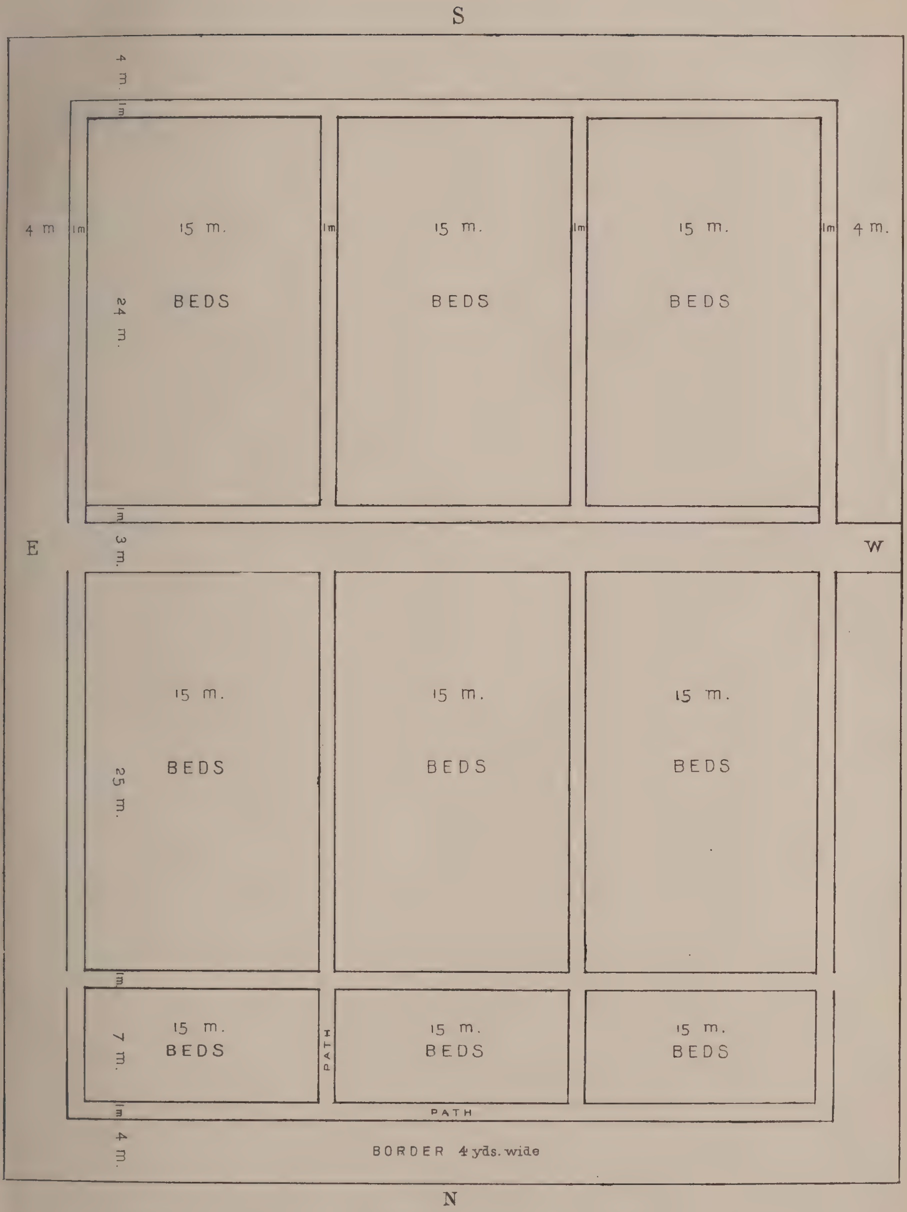
[1] M. Bagneris, *loc. cit.*, p. 212.

Pl. II.



Plan of Nursery reserved for all valuable Seeds and such as require extra care and protection.

Pl. III.

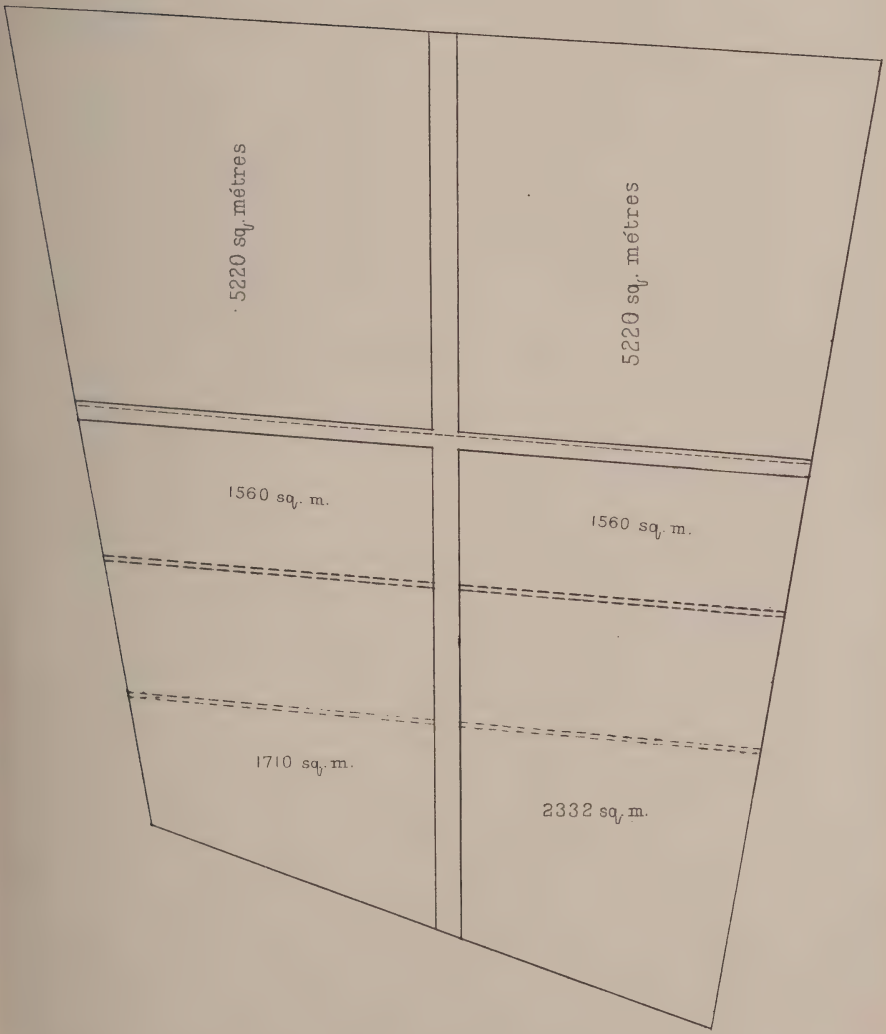


TOTAL AREA OF BEDS 3517 sq. métres, or 4220 sq. yards.

Scale $\frac{3}{16}$ in = 1 métre

Plan of Nursery,—the largest Squares reserved for Hardy Pine Screenings in drills and full beds, where extra strong Plants are desired.

PLAN OF NEW GROUND.



Scale $\frac{1}{16}$ in. = 1 métre.

Nursery devoted to transplanted Pines and other subjects, and to all rough Screenings, such as Oaks, Chestnuts, Beech, etc.

thrown into rough ridges, so as to expose the soil fully to the influence of the weather throughout the winter and early spring. In the process of trenching, all roots, stones, clods, and tufts of coarse grass, should be collected and carefully removed. Nothing should be left in the soil that can impede the growth of the young plants. When it is found necessary to trench to a greater depth, it will be found better economy to loosen the third spit in the trench, than to bring it up to the surface.

In the month of February or March, according to latitude and climate, the ground may be made level with the harrow, and then the squares and foot-paths can be laid out. One metre is generally a sufficient width for the latter. After this, and before the beds are made, the ground to be cultivated should be thoroughly dug over again with a five-pronged fork to the depth of a full spit, and the soil should be reduced to the finest possible state of division.

In the majority of instances the whole of the ground enclosed will not be needed for nursery purposes during the first year, but it should not on this account be left uncultivated. There are several crops that can be put down, with the certainty that they will pay their expenses, and greatly improve the condition of the soil for the reception of seedlings at a later date. In this case preference may be given to crops that only occupy the ground for a short time, that can be weeded easily and at slight cost, and that on or after their removal necessitate a fresh stirring up of the soil. These have a cleansing and purifying effect on the land, and do not impoverish it. Previous to sowing these—of which potatoes, kidney beans, buckwheat, and peas, are the most suitable—a liberal application of manure should be given. Some recommend cereals, roots, or even rye-grass, but these occupy the ground too long and encourage the growth of weeds.

It will be observed in Plate III. that there is a side border four metres wide all round the nursery. This is chiefly devoted to rare and delicate varieties of Abies and other subjects requiring special care. M. Carrière, like most professional nurserymen, in his designs of nurseries, places these on either side of the main road that passes across the ground transversely. The effect is decidedly better, but so far as practical utility is concerned the side border should have the preference.

Systematic arrangement is a matter of no small importance in the laying out of the nursery ground, and the nature, number, and requirements of the future seedlings must be considered on laying out the squares. This is advantageous, not only in view of the general appearance of the nursery, but also on economic grounds. Thus the pines should be kept together in a compact and clearly-defined block. They may be followed by larches, Abies, Picea, and any other conifers that may be grown. Leguminous plants, if grown to any extent, should have a compartment to themselves. Hornbeams, ashes, beeches, maples, and cherry-trees may be thrown in together, and all the larger-seeded kinds, that are sown on a rougher system, such as walnuts, caryas, horse and sweet chestnuts, and oaks, may be kept by themselves. A nursery in which seeds are tumbled into the ground as though an indiscriminate shower of them had fallen from the heavens presents a very unsatisfactory and ragged aspect, even in cases where the plants are not raised for inspection and sale.

The square must now be raked over thoroughly, and the surface soil made as fine as possible, after which, all that remains to be done is to mark out the beds. (*See* Plate II.) These should always be laid out across the slope horizontally. Their length is immaterial, although about twenty or twenty-five yards is a safe limit. The width is of far greater importance, as the centre must be within easy reach of the intermediate paths, so as to avoid all risk of the edges being trodden on in the subsequent operations of sowing and weeding. About one metre (or say three feet six inches) will be found a convenient breadth. Some raise their beds a little above the level of the paths, but save in very heavy retentive soils this is a questionable advantage. On the other hand, they may be made flush with the ground, if the latter has been well prepared to a sufficient depth. On no account should they be sunk.

In Sologne there are three distinct methods of sowing in vogue. The first, and that most generally employed for seeds of medium or small sizes—like those of Cerasus or Gleditschia, down to those of *Abies Mertensiana* and Sequoia—is to employ somewhat wide drills made with a thrust hoe,[1] or *ratissoire*, which is set on a long handle. The depth of the drill depends on the size of the seed and the extent to which it needs to be covered. This is the most expeditious as well as the simplest method for general purposes. Thus a bed of one metre in width will hold four seed drills of seven centimetres each (two and four-fifth inches), with intermediate spaces of eighteen centimetres (seven and two-fifth inches) each. The drills are made right up to the edge of the thirty centimetre (one foot) paths that intervene between the beds. The same tool is used subsequently for weeding between the drills when the young plants have come up and are fairly established.

The second practice is that of making single drills with a sharp-pointed hoe or pick. This is only resorted to for seeds of a certain size, or for such as require extra space or care during their development; such as the larger-seeded pines, Salisburya, etc.

The third method is very much the same as that recommended by Dr. Brown in *The Forester* [2] for the sowing of oaks, beech, etc., viz., that of sowing in wide drills, which are opened out with a shovel to the requisite depth, the seeds being laid at suitable distances in the trench so made. The width of the blade of the shovel is allowed between the drills, and the soil taken out in the formation of the second drill is employed to cover the seeds placed in that already sown. This method applies to walnuts, caryas, chestnuts, acorns, and the like.

A different practice has been tried successfully, in the sowing of birch and alder seeds, by Mr. David Cannon.

The seeds are sown with sand towards the end of April, after having been stratified in sand for about a fortnight. They must be sown thus late, although moisture is required, because "the seed, after having been once stored, is liable to rot from the effect of cold and wet, if it remains any time in the ground." [3]

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[1] The blade of this tool is seven centimetres (two and four-fifth inches) wide by nine centimetres (about three and a half inches) in length, set in a somewhat curved neck.

[2] *The Forester*, chap. xii., p. 488, *et seq.*

[3] Since the above was written, the author has found that it is preferable to sow during November or December, and to cover the seeds with pine needles or other light, dry litter, the covering being removed when the seeds are fairly up in April.

The soil must be very fine, and a very slight depth should be taken from the beds and placed upon the paths, so that the former may be under their level, for the sake of coolness and facility in watering. "After sowing, the surface should be lightly pressed down with a wooden beater. These beds must never be allowed to get dry until the young plants are up and can take care of themselves."

The depth at which the seed should be sown is a most important matter, and in determining this the three chief factors that are called into play during the process of germination must be carefully considered. These are very simply and precisely defined by Mr. Thomson in the *Gardener's Assistant* as follows:—

"A seed cannot germinate without a certain amount of moisture, air, and heat. Moisture softens the integuments of the seed, and relaxes the tissue of the embryo itself; atmospheric air supplies oxygen, wherewith carbonic acid may be generated by the seed, and also nitrogen, which is found experimentally to disappear in all cases of germination; while a temperature above 0° C. excites the vitality of the embryo, and enables it to take advantage of the agents in contact with it."

In general, the less seeds are covered, consistent with their receiving a sufficient supply of moisture, the better their growth; as a rule, seeds are sown unnecessarily deep. The following series of interesting experiments were made by Professor Bauer of Hohenheim, in the case of seeds of *Pinus sylvestris*:[1]—

> "Those buried one-fifth of an inch (half a centimetre) came up first, but were subsequently less vigorous—they soon, however, acquired vigour;
>
> Those covered from one-third to one-half of an inch came up more slowly, but evenly and strong;
>
> Those buried from two-thirds of an inch to one inch came up in deficient numbers; and
>
> Those buried from one to two inches never showed any signs of germination."

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[1] Consult *Manuel du Cultivateur de Pins en Sologne*, par David Cannon, para. 131.

The above statements are equally applicable to the sowing of other seeds, if their relative size and the hardness of their covering are taken into account. Thus, while the seed of *Pinus sylvestris*, even in the lightest soil, is placed at an average depth of one centimetre (two-fifths of an inch), that of *Pinus strobus*, *P. austriaca*, and *P. laricio* may be placed at half an inch. The seed of the larch, owing to the smallness of its kernel and the hardness of its outer covering, requires not only to be steeped for some days previous to sowing, but also to be covered very lightly with exceedingly fine soil.[1]

If hardy forest seeds are sown early and with care on well-cultivated ground, it is but seldom necessary to resort to watering; still, in the case of very minute seeds in very dry soils, it is better to supply them with moisture artificially until germination has taken place, and the seedlings have gained some strength, than to check the growth at starting or to cover the seeds too deep. At the same time, the latter should never be allowed to become water-logged, as in such circumstances the free oxygen of the air is unable to act on them, and decomposition sets in. Where space is not very limited, and fine stout well-furnished plants are the object aimed at, seed of good quality should be sown thinly, allowing, in the case of *Pinus sylvestris*, not more than one seed to the half-inch square. If sown thickly the seedlings become weak and drawn, and their roots are feeble and badly furnished with fibrous rootlets. Even for transplanting at the age of one year, stout healthy plants are to be preferred.

The testing of the quality of the seeds supplied is a very important matter.

"To ascertain," says M. Bagneris, "whether seeds are good, they are opened, if large enough, with a penknife, and examined; the kernel ought to completely fill the cavity of the shell, it should be white (except in the ash, in which it is bluish; and in the maple, in which it is green), and moist, and the plumule should be entire. If the seeds are small, they ought, on being crushed by the nail, to leave traces of moisture more or less milky, and in the case of conifer seeds, to omit an odour of turpentine. . . . If two-thirds of the seeds are good, the whole lot may be considered of good quality."

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[1] Since the above was written, the author has adopted the practice of sifting the necessary depth of soil over all fine seeds.

Another ingenious method of determining the quality of seeds is described by M. L. Digeon[1] as follows :—

"By this trial you can determine in a few seconds the value of the seeds that are offered for sale.

"Take at hazard from the same bag an even number of seeds, say eight for example; take up on a fire-shovel a few bits of live charcoal, and on these lay the seeds singly, keeping up the flame with your breath, and watching attentively with your sight the various phases of combustion. If this takes place slowly, merely allowing a little smoke to rise, you may be sure that the germ of the seed is unsound. Continue the trial, seed by seed, never taking your eyes off the effect produced.

"If all the seeds burn as did the first one, you may rest assured that the bag from which you took your sample is of no value, and that you must seek a fresh supply from another source. If, on the other hand, the whole or a part of the seeds tested spring up or turn over on the live coal, emitting at the same time a crackling report, loud in proportion to the size of the seed, you may be satisfied that each of these seeds possesses all the properties essential to germination. But if out of the eight seeds only four crackle in burning, you may safely determine that but 50 per cent. of the seed is of good quality.

"This process is applicable to all seeds."

Although the above test may answer very well in the case of most Pine seeds, its efficacy in the case of seeds of *Corylaceæ*, *Drupaceæ*, and others of large size with fleshy kernels, seems doubtful.

I have found in my practice that although old seeds may not have lost their power of germination, their vitality is much impaired, as also is the constitution of the seedlings raised from them. There are, of course, certain exceptions, but not many.

At Barres the seeds are tested by being laid in a wet flannel or seed-pan, and subjected in a frame to a heat varying from

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[1] *Journal d'Agriculture Pratique*, 9 Mars 1882.

15° to 20° C. for three weeks. This is a lengthy and tedious process, but still a certain one.

There are many kinds of seeds, notably those with a hard covering, which it is advisable, if not absolutely necessary, to steep in water, or better still, in a solution of liquid manure, previous to sowing. Some steep all their Pine seeds, but this is not necessary in Sologne, save in the case of *P. strobus*, *P. excelsa*, *P. Lambertiana*, and other five-leaved varieties, in which the process of germination is always much delayed. This process is advisable with some of the Abies and Piceas, and notably with the larch, which may be steeped without danger for a whole week. Most leguminous seeds come away the better if steeped for a few days.

There are certain seeds that do not as a rule come up until the second season, such as hornbeam, ash, liriodendron, sorbus, crataegus, berberis, and the like. It is always a waste of ground, time, and money, to sow these in the beds in the first instance. As a rule, therefore, they may be stratified in the open with sharp river sand,[1] and turned early in the following spring. Many sow these seeds so soon as they are ripe, but spring sowing is preferable.

Some seeds keep with difficulty, and M. Bagneris suggests that they should be sown as soon as ripe and gathered. The seeds of the elm, birch, and alder are of this nature. Instead of this method, I should prefer to gather and stratify with sand, in a cool place, guarding against undue damp, until spring.

Again, in the case of the walnut, sweet and horse chestnut, acorns of all sorts, cherries, and others with fleshy kernels, the seeds should be stratified through the winter under cover, with dry sand, in a cellar or other cool and dry place. The sweet chestnut, in particular, has a tendency to sprout very early, unless kept in a low temperature. They may all be sown early in spring. Many use powdered charcoal in lieu of sand; it is perhaps a better absorbent of excessive moisture.

"Among Conifer seeds," says M. Bagneris,[2] "that of the silver fir requires great care. They must be handled as little as possible, their wings should be preserved, and they must be gathered near the spot intended to be sown."

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[1] River sand will always sift away easily, whereas soil, however light, is always troublesome.

[2] M. Bagneris, *loc. cit.*, p. 208.

Again :—

"For a long time at least it was believed impossible to raise beech and silver fir in open nurseries, on account of the delicate constitution of the young plants of these species. It had, nevertheless, been observed that beech seedlings taken from the forest at the moment of germination could be transplanted in an open place, provided they were put into the ground up to the cotyledonary leaves. The fact is, that it is the young stalk which is the most sensitive part. Hence a new plan has been devised for these species. Narrow trenches are dug, and the earth heaped up at the edges, so that the trenches have a depth of about four inches. The seed is sown at the bottom, and as the young plants grow up the earth is put back into the trench, till the ground becomes level. This plan has never failed, especially when care was taken to dig the trenches east and west, so as to shelter the seedlings on the southern side."

Where it is considered unnecessary expense to put up shading, this method may be advantageously followed; but satisfactory results may be obtained by sowing in the ordinary way, and giving shelter when the plants begin to push.

A good deal of difference of opinion exists as to the time when sowings should be commenced. Many excellent authorities (the French Government included) are in favour of not sowing before April, in spite of the short time that is allowed for the plants to gain strength before the trying heat and drought of the summer months set in. In the Sologne, general sowings of hardy pines, oaks, chestnuts, and the like, are commenced in the first week of March, provided the weather is open and the ground in a suitable condition. No ground should be worked while under the influence of frost. The leguminous plants and more tender Piceas are left to follow in the first week of April; and at the same time reserve sowing of the hardier pines, and of larch, is made. By the fifteenth of this month forest-tree sowings are pretty well completed.

Nothing has occurred as yet to afford the slightest reason for altering this course of procedure; on the contrary, the development of the plants has been very remarkable, and the results as good as could be wished for. The adoption of this plan, shelter being given as necessity arises to such tender subjects as may stand in need of it, enables one to make the most of the moisture contained in the ground during the early spring months; and by the time the surface becomes dry, the roots of the seedlings have attained a sufficient depth, and their upper growth is sufficiently set to enable them to bear many hardships. Germination is indeed slower, but it is not less assured. Later sowings, in any case, would be attended with great risk to the satisfactory growth of the plants. The spring season in Sologne is about three weeks or a month earlier than that of the south of England, and the climate is more forcing.

Seeds must undergo a preparation previous to being put into the ground, otherwise the ravages of birds and field-mice will leave but a slender percentage to come up. Dressing all seeds with red lead is very advantageous. The seeds are placed in a tin vessel, moistened with a few drops of water, and then shaken about so as to damp the surface of each evenly; a little red lead is sprinkled over the mass, and shaken again. The seeds will be found perfectly coated, and no injury occurs even in the case of the most delicate varieties. The attacks of birds and field-mice are thus averted.

CONIFERÆ.

The following notes on the Coniferæ will be as concise as possible, on the questions of duration, habits, and uses. Some of those mentioned are purely ornamental varieties, but as they are hardy, and certain to be more or less in demand in most cases in which nurseries are established, it has seemed advisable to give them a place. The species referred to are given in alphabetical order.

1. *Abies alba*, the White Spruce, is an ornamental variety seldom exceeding 45 or 50 feet in height. It is a native of North America. Dr. Brown speaks highly of the effect produced by it when planted in conjunction with pines and *Acer saccharinum*. *A. cœrulea* is a variety with more glaucous foliage. The seed should be sown in the same manner as that of the common spruce (*A. excelsa*).

2. *Abies* (*Tsuga*) *canadensis*, the Hemlock Spruce, is a native of North America. In Mr. Thompson's *Gardener's Assistant* it is well spoken of as a "very hardy, fast-growing, and very graceful tree," succeeding well in damp situations (as do all the *Tsuga* class). Its height varies from 50 to 80 feet. The seed may be sown in the same manner as that of the common spruce, but it should be covered as lightly as possible.

3. *Abies* (*Pseudo-Tsuga* of De Kirwan)[1] *Douglasii*, the Douglas Fir, is also a native of North America. In its native country it attains a height varying from 150 to over 250 feet. It is probably the most important of all exotic firs from the forester's point of view, and there are few sites or soils in which it will not thrive and make luxuriant growth. Dr. Brown recommends that it should be planted as permanent timber at intervals of twenty feet, and that larches should be used as nurses. The *Gardener's Assistant*[2] states that it is not suitable for exposed places on the coast. I have, however, seen young trees not far from the sea thriving well in Brittany. In all parts of France where I have observed it, its growth has been marvellous, far exceeding that of the common spruce under the most favourable circumstances. In the Botanic Garden at Tours there are some excellent specimens of young trees. The seeds should be sown in the same manner as those of *Pinus sylvestris*, but somewhat more thinly, so as to encourage a vigorous and stout growth. On account of the fact that it starts early into growth, this variety does not always escape the action of spring frosts in exposed situations during the first few years of its existence, and it may therefore need shelter in the nursery.

4. *Abies excelsa*, the Common Spruce, is a native of Northern Europe. Its height may reach 150 feet. This species occupies among firs the place that *P. sylvestris* does among pines. It is the hardiest, the most indifferent with regard to soil (so long as the latter is not too dry), and the most generally useful species. It may therefore well be taken as a typical subject, and the remarks that apply to the sow-

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[1] *Manuel des Conifères*, par E. de Kirwan, Inspecteur des Forêts.

[2] *Gardener's Assistant*, p. 633 *et seq.*

ing of its seeds will hold good in the case of all other species of Abies.

The drills should be made in the same manner as those recommended for *Pinus sylvestris,* but should be a little less deep. They should not be sown too thickly, as the seedlings have to remain two years in the seed-bed previous to transplantation, and they make but slow growth at first. Here it may be noted that in the climate of Sologne both Abies and Piceas require shelter from the sun at the time of germination, and until the plants have gained some strength, and that the young shoots are liable to be frozen during the following spring in the event of their making too early growth.

5. *Abies Menziesii,* the Menzies Silver Fir, is a native of North America. Its height may be 80 feet. The seeds may be treated like those of *A. excelsa.* The first year's growth is very small.

6. *Abies* (*Tsuga*) *Mertensiana* (*A. Albertiana* or *A. Sitchensis*). Prince Albert's, or Sitcha Fir, is a native of the island of Sitcha. It attains a height varying from 80 to 100 feet. It deserves extensive cultivation as a forest tree, and strenuous efforts are now being made by the German Government to have it cultivated in the State forests on a large scale. Like *A. canadensis* it delights in moist situations. It is perfectly hardy, and of free and rapid growth. The seeds should be sown like those of *A. canadensis.*

7. *Abies Morinda* (or *A. Smithiana*) is a native of the Himalayas. Its height varies from 80 to 100 feet. It is a very handsome ornamental tree of drooping habit. It is tender in spring. The seeds may be sown like those of *A. Douglasii.*

8. *Abies nigra,* the Black Spruce, is a native of North America. Its height varies from 80 to 100 feet. Dr. Brown speaks of this as a tall slender tree seldom exceeding twenty-four inches in diameter. It is perfectly hardy, and grows in a great variety of soils.

9. *Abies Orientalis,* the Eastern Spruce, is a native of Asia Minor. Its height may be 40 feet. It is a handsome ornamental species, of a lighter hue than that of the common spruce. It is held in some favour in France, where it seems to be perfectly hardy, but it is of very doubtful value as a

forest tree. The seeds should be sown like those of the common spruce.

10. *Cedrus Atlantica*, the Mount Atlas Cedar, is a native of North Africa. In height it may reach 80 feet. The cedars are hardly forest trees, nevertheless for their effect they are in great demand. This species grows more quickly and more freely than the two following, and is that most cultivated in France. Its seeds should be sown like those of *Picea pectinata*, only somewhat thinner, say one seed to every four square inches, if it is fresh and good. All the cedars should be transplanted into nursery lines at the end of the first season.

11. *Cedrus deodara*, the Deodar Cedar, is a native of the Himalayas. Its height varies from 150 to 200 feet. It is by far the most beautiful of the cedars, perhaps of all trees. It is sometimes liable to be injured by spring frosts when young. It may be treated like *C. Atlantica*.

12. *Cedrus Libani*, the Cedar of Lebanon, is a native of the Levant. Its height may be 100 feet. It may be treated like *C. deodara*. There are several nurserymen's varieties of all these cedars, but they call for no comment.

13. *Cupressus Lawsoniana*, Lawson's Cypress, is a native of California. In height it reaches 100 feet and upwards. It is a singularly handsome tree, and deservedly in favour for ornamental purposes, although, in spite of its dimensions, it can hardly be recommended for the purposes of forestry. It is generally raised by nurserymen from cuttings, but where upright free-growing specimens are desired, seedlings are much to be preferred. The only objection to plants so raised is, that from the number of varieties which exist, they cannot be depended on to come true to type. They make but little growth during the first season, and are subject to frost during the first two or three years. The seeds should be sown like those of *Abies canadensis*, and should be covered very lightly with fine mould. This should be sifted over the seed, and lightly pressed down with the wooden beater recommended for birch sowing.

14. *Cupressus macrocarpa* is a native of California. Its height is 60 feet. It is a very handsome fast-growing variety,

specially recommended in the *Gardener's Assistant*[1] for the south and west coasts of England and Wales.

15. *Juniperus Virginiana*, generally known as the Virginian Red Cedar, is a native of Canada and the United States. Its height is 50 feet. Dr. Brown states that the tree thrives as well in this country as in its native woods; that its timber is much sought after in America for cabinet purposes and turnery, and also that its wood is that employed for making black-lead pencils. As the seeds do not come up during the first season, they should be stratified in sand, and sown early in the following spring. The tree is very hardy, and deserving of a place in our forests. The seeds should be sown like those of *Abies Douglasii.*

16. *Larix Europæa*, the Common Larch, is a native of Central Europe. Its height reaches 100 feet and upwards. Most of the seed in commerce is derived from the Tyrol. The tree and its uses are well known. The seed may be sown in the same manner as that of *Abies canadensis*, after it has been well steeped, and it should be covered very lightly with fine soil. In Central France it decidedly needs protection against hot suns during germination. It should be sown very thickly, as a germinative power of 33 per cent. is not often exceeded. It suffers more from the attacks of the rabbit than most other plants. The seedlings should be transplanted into nursery lines at the end of the first season.

17. *Picea amabilis*, the Lovely Silver Fir, is a native of Northern California. Its height is 200 feet. It is perhaps the most magnificent of the whole family of firs, and save in its earliest stages it is perfectly hardy. The seeds are sometimes very difficult to procure. They should be planted like those of *Abies Douglasii*, twenty feet apart, and larch should be used as nurses. It is tender in its early stages, and it develops a powerful tap-root. It should be sown in basket pots, and in most cases sheltered from frost for the first two winters. It makes a better growth during the first year than do most of the Piceas. It will, in common with the rest, require a second transplantation when three or four years old.

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[1] Page 663 *et seq.*

18. *Picea balsamea*, the Balm of Gilead Fir, is a native of North America. Its height is 45 feet. It is a very pretty little hardy fir, very useful for ornamental purposes, and highly popular in France, but it is of questionable value as a forest tree. The seed is very small as compared with most other Piceas, but may be sown in the same manner as that of *P. pectinata*, only thinner, say one seed to every two square inches. It should be covered lightly (say to a depth of one-third of an inch). All Piceas should be protected with some light shading when they first come up, for until their tender stems have somewhat hardened, they are very susceptible to injury from both sun and frost.

19. *Picea bracteata* is a native of California and Oregon. Its height is 130 feet. It is a very beautiful fir, either for the forest or for ornament. It grows naturally, according to M. de Kirwan, at great elevations on the central ranges of the mountains, and is capable of withstanding great extremes both of cold and poverty of soil. The seed is far easier to procure than that of *P. amabilis*, and may be treated like that of *Picea pectinata*.

20. *Picea Cephalonica* is a native of Cephalonia. Its height varies from 60 to 80 feet. It is said by M. de Kirwan to be identical with *P. Apollinis*. It is a singularly handsome and valuable variety, and judging from its appearance in the Botanic Garden at Tours, it is perfectly hardy and of rapid growth. It is decidedly worthy of the forester's notice. It may be treated like *P. pectinata*.

21. *Picea concolor* is a very rare and beautiful plant, and is a native of the mountains of Mexico. It should be treated like *P. balsamea*.

22. *Picea grandis* is a native of Northern California and British Columbia. Its height varies from 150 to 200 feet. It bears so marked a resemblance to the foregoing that M. de Kirwan includes them both, together with *P. lasiocarpa* and *P. magnifica* as a single species. They are, however, likely to prove distinct. *P. grandis* is well worthy of cultivation as a forest tree, and may be treated in the same manner as *P. balsamea*.

23. *Picea lasiocarpa* (*Parsinsii* or *Loweania*), is a native

of California. Its height is 250 feet. It is only known to us as an ornamental tree. It may be treated like *P. grandis.*

24. *Picea nobilis* is a native of Oregon. Its height varies from 150 to 200 feet. This species deserves extensive cultivation, both ornamentally and as a forest tree. The seed is not so expensive as to prevent it from being propagated on a large scale. It may be planted out as recommended for the Douglas Fir. Once established, the tree is perfectly hardy and of excessively rapid growth, shoots being sometimes fully three feet in length. The seeds may be sown like those of *P. pectinata.*

25. *Picea Nordmanniana* is a native of the Crimea. Its height varies from 80 to 100 feet. It may be said to be the hardiest of all the silver firs. Dr. Brown states that it has never been known to be frozen, even in the earliest stage. It is by far the most valuable of all the silver firs for the purposes of general forestry in our climates, and fresh seed can be procured without difficulty. Several remarkably healthy and free-growing specimens may be seen in the Botanic Garden at Tours. It may be treated like *Picea pectinata.*

26. *Picea pectinata,* the Common Silver Fir, is a native of France. Its height is 150 feet. It occupies among the Piceas the same position that the common spruce does among the Abies, and is equally extensively cultivated in those climates and soils that are suited to its requirements. It prefers mild moist climates and light soils. It is impatient of extremes of heat and cold, and very tender when young. It is more tender in the nursery than any of the imported Piceas.

"The tree throws out," as M. Bagneris says,[1] "a long tap-root where the ground is sufficiently deep; but it soon produces strong lateral rootlets, which allow it to establish itself and thrive in superficial soils, and even on rocky ground.[2] A free moist soil of a sandy or calcareous nature is best adapted to the silver fir. It avoids clayey and damp soils, where rot speedily attacks its roots."

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[1] M. Bagneris, *loc. cit.*, p. 76.

[2] Wonderful examples of this may be seen in Brittany.

The seed may be sown in wide drills made by the *ratissoire*, allowing three or four square inches for each seed if the sample is a good one, and it should be covered to a depth of half an inch. From germination until the growth is hardened, the young plants are very tender, and liable to injury from frost and sun. They must therefore be carefully shaded. They also require protection against frost in spring until they are at least three or four years old. They make but very slight growth during the first year, and will not be ready to transplant into nursery lines until after the second. Their natural habit of growing under shelter till an advanced age renders them troublesome in a nursery. All the other varieties are far less tender than the common silver fir.

27. *Picea Pindrow* is a native of the Himalayas. Its height is 100 feet. It is a fine hardy ornamental tree, but sound seed is hard to procure. It may be sown like *P. Nordmanniana*.

28. *Picea pinsapo* is a native of Spain. Its height varies from 70 to 80 feet. It is a handsome tree, easily distinguished by its rigidity of habit and foliage. As a forest tree it has not received the attention it deserves. M. de Kirwan states that it is a hardier and more robust plant than the common silver fir (*P. pectinata*), and from its starting later into growth it suffers less from spring frosts. My own experience fully confirms this view. It is more easily pleased, too, in the matter of soil. It should be preferred for all inland or exposed situations. A handsome variety is obtained from the Babor Mountains in North Africa. The seed may be sown like that of *P. pectinata.*

29. *Picea Regina Amelia* (or *P. Peloponnesica*) is a native of Greece. Its height is 70 feet. It is a form very closely allied to *P. Cephalonica*, and should receive the same treatment.

30. *Pinus Austriaca*, the Black Austrian Pine, is a native of Austria. Its height is 80 feet. It is one of the hardiest forest trees we possess, making under certain conditions even better growth than the infallible Scots pine. It is, however, less suited than the latter for sowing on heather lands. Its growth in the Sologne is not eminently satisfactory ; but in the dry cretaceous plains of Champagne, in Brittany, and in a great

variety of other soils and climates, it makes great progress. After *P. maritima* it endures proximity of the sea better than any other species. It is not, however, proof against the rabbit when young. It should be sown in drills like *P. sylvestris*, but more thinly and a little deeper, say from one-third to half an inch.

31. *Pinus Benthamiana* is a native of California. Its height is 200 feet. It is a very handsome, hardy, fast-growing, and valuable forest tree, and is well worthy of cultivation on a large scale. As the seeds are large and the plants valuable, they may be sown in single drills about three-quarters of an inch in depth, allowing from two to three inches from seed to seed. If sown in the wide drills the seeds must be laid down sparingly.

32. *Pinus Coulteri* (or *macrocarpa*) is a native of California. Its height varies from 80 to 100 feet. Dr. Brown speaks very highly of this tree, but he recommends that it should be kept in a frame during the first winter. It attains considerable dimensions during the first season, and in some seasons may be successfully wintered in the open without protection of any kind. It should, however, receive the same shelter as the Piceas. The seeds, being very large, should be sown from four to six inches apart in single drills. They should be covered to the depth of an inch with light soil. Owing to their developing abnormal tap-roots, they should be raised either in basket pots or the tap-roots should be shortened in the ground in autumn by the spade. They should be shaded from the time of coming up until they are well established.

33. *Pinus excelsa* is a native of the Himalayas. Its height is 120 feet. It is by far the most ornamental of the five-leaved section of pines, perhaps of all pines in general cultivation, and it is perfectly hardy. As the seeds take a long time to germinate, and make but little progress during the first year, they should be steeped for some days previous to being sown. This may be done thinly in wide drills, though basket pots are to be preferred. They will not be ready for transplanting into nursery lines until the second season.

34. *Pinus insignis* is a native of California. Its height varies from 80 to 100 feet. It is one of the most striking and

beautiful of all ornamental pines, chiefly noticeable for its vivid green foliage. It attains considerable size during the first season and transplants freely; though it will be all the better if its tap-roots are cut with the spade in autumn. The seeds should be sown in single drills from half to three-quarters of an inch deep, and three inches should be allowed from seed to seed.

35. *Pinus Jeffreyana* is a native of California. Its height is 100 feet and upwards. Dr. Brown states that it needs a warm corner, with good soil and protection against frost during the first winter, after which it becomes quite hardy. The seeds should be sown in single drills or very thinly in the wider ones.

36. *Pinus Lambertiana* is a native of Northern California. Its height varies from 150 to 200 feet. As *P. excelsa* is the most ornamental, so this is the most valuable of the five-leaved section of pines, and it is certainly one of the most serviceable forest trees that have been introduced into this country. The seeds germinate much sooner than those of any others of this section, save, perhaps, *P. strobus,* and the seedlings attain a fair size during the first year. They should, however, be left in the nursery beds for two seasons. It is far more easily accommodated in the matter of soil than are most exotic pines, and it comes away freely in light, sandy, and poor soils. The seeds are large, and should be sown somewhat thinly in single drills. They should be covered to a depth of about three-quarters of an inch. The young plants are perfectly hardy.

37. *Pinus laricio, var. Calabriæ,* the Calabrian Laricio Pine, is a native of Southern Italy. Its height is 150 feet. It is one of the most valuable forest conifers known, especially in soils that favour its development. Dr. Brown states, in speaking of the common laricio (which he evidently confuses with the one now under notice), that it grows more rapidly and yields a greater amount of produce, all circumstances being alike, than does the Scots pine. It certainly is one of the most important, if not the most important, of all European pines. The seed is, however, very scarce and difficult to procure. It may be sown like that of the Austrian pine,

and the seedlings (if of the average size) should be transplanted into lines at the end of the first season. Forty per cent. is by no means a bad proportion of sound seed in the case of this species. One of the great advantages attached to the laricios is their immunity from the attacks of ground game.

38. *Pinus laricio, var. Corsicæ*, the Corsican Laricio, is a native of Corsica. Its height is 120 feet. It differs but little from the preceding save that its growth is not so vigorous, and that its habit is less regular. Its size, too, is less, and it is decidedly inferior to it as a forest tree. It is, however, much cultivated, the former being as yet but little known. The seeds should be sown in the same manner as those of the Calabrian variety, and the seedlings should be transplanted into nursery lines at the end of the first season.

39. *Pinus Monspessulana* (*Pyrenaica*, *Cevennensis*, or *Sabiniana*) is a native of the Cevennes, Montpellier, Pyrenees, and other parts. It is also known to French foresters as the *Pin d'Aless major* and *Pin de St. Guilhem*. All the above titles are probably given to mere types of a single variety, and it is very closely allied to *P. Austriaca*, from which it may be chiefly distinguished by the lighter and brighter colouring of its foliage, the greater length of its leaves, its more rapid growth (in certain soils and climates), and regular habit, and lastly, by being less exacting in the matter of soils. Unfortunately great difficulty is experienced in procuring seed of this beautiful and useful forest tree. It is found to make excellent growth in those sandy soils and dry climates where the Austrian pine fails to succeed thoroughly. The seeds should be sown in the same manner as those of *Pinus Austriaca*.

40. *Pinus Pallasiana* (or *Taurica*) is a native of the Crimea. Its height is 100 feet. This is a pine of very much the same characteristics as the Laricio. Dr. Brown recommends it as a fine spreading tree of rapid growth, and as being very hardy, and indifferent in the matter of soils. It is deserving of very extensive cultivation as a forest tree, being one of the most valuable that has been introduced. It should be treated like *Pinus Austriaca*.

41. *Pinus Parryana* is a native of California. MM. Vilmorin Andrieux speak of it as perfectly hardy, and bearing

a strong resemblance to *P. Benthamiana.* It will require the same treatment.

42. *Pinus pence* is a native of Greece. This is a form of *P. strobus,* and requires the same treatment. It cannot be recommended as a forest tree in our climates.

43. *Pinus ponderosa,* the Heavy-wooded Pine, is a native of California. Its height is 100 feet. It is fast-growing and hardy, and is well deserving of cultivation as a forest tree for the sake of its timber. It should be treated like *P. Benthamiana.* The plants are fit to go out into nursery lines at the end of the first season.

44. *Pinus resinosa* is a native of Canada. Its height is 80 feet. Dr. Brown speaks very highly of this tree, on the score of its hardiness, rapidity of growth, and the value of its timber, and the same opinion seems to prevail among French foresters. The seed is very difficult to procure. The treatment given to the Austrian pine will probably suit it best.

45. *Pinus rigida,* the Pitch or Swamp Pine, is a native of North America. Its height is 50 feet. It is in considerable demand, and deservedly so, though it hardly attains first-class dimensions. It is very hardy, a rapid grower, and succeeds in soils where most others would fail. Its only drawback is its great liability to be attacked by the rabbit. The seed should be sown in the same manner as that of *Pinus sylvestris.*

46. *Pinus Sabiniana* is a native of California. Its height is 120 feet. It is a very handsome strong-growing variety, but requires a good soil, and is somewhat tender in its earlier stages. It should be treated like *P. Coulteri,* and the tap-roots should be cut *in situ* at the end of the first season, otherwise it will only transplant with the greatest difficulty.

47. *Pinus strobus,* the Weymouth Pine, or Yellow Pine of America, is a native of Canada. Its height is 200 feet. This magnificent and useful tree is a familiar object. In Europe it is grown as an ornamental rather than as a forest tree, and the timber it produces is said to be much inferior to that imported from America. The rapidly approaching extinction of this species is at present causing much anxiety to those interested in the forests of America. The seeds take a long time to germinate, and should therefore be steeped for some time

previous to sowing. They may be sown like those of the Austrian pine. The young plants should not be placed in nursery lines until the end of the second season.

48. *Pinus sylvestris*, the Scots Pine, is a native of Northern Europe. Its height is 140 feet. It is the best known, most generally cultivated, and to the forester the most useful of our hardy pines. It exists in three markedly distinct types, viz., the Riga, the true Scots, and the Geneva Pine; and it has been clearly established in France that these varieties transmit their characteristics without change to their offspring. At the Domaine Forestier of Barres Vilmorin, in Brittany, and elsewhere, it has also been equally clearly proved that the Riga variety is, on account of its regular, upright habit of growth, and the quality of its timber, decidedly superior to the other two as a forest tree. Its growth is not, as some assert, less rapid. The seed should be sown in wide drills made with the thrust-hoe or *ratissoire*, and covered but lightly with fine soil to a depth of one centimetre (two-fifths of an inch) at the outside. They must not be sown too thickly, if stout vigorous plants well furnished with fibrous roots are desired,—one seed to the square inch being quite close enough. Weak, crowded, drawn plants are good for nothing, and will never develop into healthy, vigorous trees, even if they do survive the risks of transplanting. The seedlings may be transplanted into nursery lines at the end of the first season.

49. *Salisburya adiantifolia*, the Maiden-hair Tree, is a native of China and Japan. Its height is 120 feet. It is a very striking and handsome tree, and in some soils and climates it is a very rapid grower. In Tours and the neighbourhood it appears to make marvellous growth. M. de Kirwan says that Professor Burge saw a tree at Pekin in full vigour, which had attained the dimensions given above. The seeds are best sown in single drills six inches apart. They should be covered with an inch or an inch and a quarter of soil. They attain no great height during the first year, seldom reaching six inches, and should receive some slight protection from frost during the first and second winter and spring. The wood is of excellent quality, and resembles much that of maple (De Kirwan). They should be planted into nursery lines at the

end of the first season. The species is well worthy of experimental cultivation for the sake of its timber.

50. *Sequoia* (*Wellingtonia*) *gigantea* is a native of California. Its height is 400 feet, and is only exceeded by certain Eucalypti. On account of its rapid growth and highly ornamental appearance, as well as its hardihood in our climate, it might be cultivated in England much more extensively than it is. It thrives with remarkable vigour at Tours, and even withstood the terrible frosts of the winter of 1879-80. The seeds may be sown in the same manner as, but somewhat more thinly than, the Scots pine, and they should be covered somewhat less deeply. They should be steeped previous to sowing. The plants must remain in the beds until the end of the second season before being transplanted into nursery lines, and they should be sheltered during the first winter. They should be again lifted at the end of the fourth season.

51. *Sequoia sempervirens* (syn. *Taxodium sempervirens*) is a native of Upper California. Its height is 300 feet. It is by no means equal to the preceding either in growth or hardiness, but it may be treated in the same manner, except that it will require to be more shaded in winter and spring.

52. *Taxodium distichum*, the Louisiana Cypress, is a native of Louisiana. Its height is 100 feet. It has been much undervalued both as an ornamental and as a forest tree. The *Gardener's Assistant*[1] describes it as "one of the few deciduous conifers which forms a handsome tree, sometimes exceeding 100 feet in height." It "succeeds best in sheltered situations and in a moderately rich moist soil." It is essentially a tree suitable for damp situations, in which it grows rapidly and freely, resisting all frosts. It is remarkably easy to propagate, and attains considerable dimensions during the first season. It must be protected from the rabbit when young. The seeds should be sown like those of *Picea pectinata*, and should be transplanted into nursery lines at the end of the first season.

53. *Thuja gigantea* is a purely ornamental tree, and on this account it is highly valued. The seeds should be sown and treated like those of *Cupressus Lawsoniana*.

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[1] *Gardener's Assistant*, p. 663.

54. *Thuja Lobbii*
55. *Thuja orientalis* } agree in their treatment with the above.

The value of the latter depends not so much on its merits as an ornamental or forest tree as on its value as a shelter from the effects of frost and wind when planted so as to form a thick hedge. Little squares of it, with a gap left for entrance on one side, are to be seen in almost every trade nursery, and within these the more tender varieties of Abies, and other scarce and costly seedlings, are placed until they have attained sufficient hardihood to bear exposure in the open. The only other plants that can, to a certain extent, take its place for this purpose are the Hornbeam and Privet, but these labour under the disadvantage of losing their leaves in winter. The Yew grows too slowly, and so, too, does the Holly. The seeds of *T. orientalis* may be sown like those of *Pinus sylvestris,* but the young plants should be left in the beds until the end of the second season.

It is to be noted that no mention has been made of certain well-known pines, on the ground that they are either not very deserving of a place in the nursery, or that their cultivation is not likely to be entertained seriously on a large scale with us. These are *P. maritima,* which is only grown *in situ* from seed; *P. pinea,* a very troublesome southern plant; *P. halepensis,* which is unsuited to our climate as a forest tree; and the dwarf mountain pines, *P. cembra, P. pumilio,* and *P. montana.*

DECIDUOUS TREES.

Deciduous trees are by no means inferior to the Coniferæ in importance, and as in the former case, the various species of interest will be referred to in their alphabetical order.

1. *Acer campestre,* the Common Maple, is a native of Britain. Its height is 25 feet. The common maple, though it can hardly be classed as a forest tree, is yet in some demand for coppice and hedgerows, more perhaps on account of the beauty of its foliage in autumn than for its value in other respects. The seeds should be sown in wide drills like those of the sycamore, but somewhat more thickly.

2. *Acer negundo* is a native of America. Its height is 40

feet. It is a singularly elegant and graceful tree, and deserving of cultivation in our forests on its own merits. It is, however, chiefly in demand as a stock whereon to graft the variegated varieties. It should receive the same treatment as the sycamore.

3. *Acer Pennsylvanicum* is a native of Pennsylvania. Its height is 40 feet. It is a handsome effective species of rapid growth, and must be treated like the preceding species.

4. *Acer platanoides*, the Norway Maple, is a native of Norway. Its height våries from 60 to 70 feet. It should be cultivated as a forest tree very much more extensively than it is. It grows very fast, is unexacting in the matter of soil, so long as the latter is free, and is essentially hardy. Dr. Brown states that it thrives close to the sea. Its timber is of excellent quality. It may be sown in the same manner as the sycamore, but its seeds should be more lightly covered (barely half an inch). It will require the same subsequent treatment as *A. pseudo-platanus.*

5. *Acer pseudo-platanas*, the Sycamore, is a native of Britain, and attains a height of 80 feet. As regards the value of its timber, adaptability to soil, and rapidity of growth, it is similar to the preceding. Its seeds are sown in beds, in wide drills made by the *ratissoire,* one seed to every four square inches being close enough. They should be covered to a depth of three-quarters of an inch. Dr. Brown recommends autumn sowing in the case of this and many other hardy seeds; but I believe that such sowings are not to be recommended, as the seeds are liable to be rotted by cold moisture, and to be destroyed by field-mice. In this and in all similar cases the seeds, when collected or bought in autumn, should be stratified in dry sand under cover throughout the winter, and should be sown early in the following March (or perhaps April in England). All young maples should be transplanted into nursery lines at the end of the first season.

6. *Acer rubrum*, the Red Maple, is a native of the United States. Its height is 40 feet. It is a handsome variety, and chiefly deserving of cultivation on this account. It should be treated like the sycamore.

7. *Acer saccharinum*, the Sugar Maple, is a native of the

Northern United States and Canada. Its height varies from 80 to 100 feet. This hardy tree has the strongest claims to the forester's attention, and is by far the most valuable of the whole family. Its cultivation, however, is still much neglected. Its timber is of great value, being the "Bird's-eye Maple" of commerce. Its growth is very rapid. Dr. Brown states that it is more particular as regards soil than the others. It requires a sheltered situation, and deep open-bottomed rich light soil. It should be treated like *A. pseudo-platanus.*

8. *Alnus glutinosa,* the Common Alder, is a native of Britain. Its height is 60 feet. It requires in the nursery a fresh, light, free soil, the surface of which should be reduced to as fine a state of division as possible previous to sowing the seed. The seed may be sown like that of birch, or in beds in wide but exceedingly shallow drills. It should be sown about as thick as that of *Pinus sylvestris,* and a light coating of fine mould should be sifted over it. The beds should then be lightly but firmly pressed down with the wooden beater or the back of a spade. The surface should not be allowed to become dry until the seeds have germinated, and they should be shaded from the time of sowing until the plants have attained a moderate size. Seedlings may be placed in nursery lines at the end of the first season. Sowing should be done during the first week of April.

9. *Alnus Incana,* the Grey Alder, is a native of Northern Europe. Its height varies from 30 to 40 feet. It should be treated like *A. glutinosa.*

10. *Æsculus hippocastanum,* the Horse Chestnut, is a native of Asia Minor. Its height is 80 feet. The seeds should be sown like those of *Quercus pedunculata,* but a much greater distance should be allowed between them, one to every four inches square being close enough. They should be covered to a depth of one and a half or two inches. Quincunx sowing is very convenient, thus :—

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They will be ready to transplant at the end of the first season. The seed should be kept stratified through the winter under cover in dry sand or crushed charcoal, and should be sown during the March following.

11. *Betula alba*, the Common Birch, is a native of Britain. Its height is 40 feet. All other varieties, such as *B. excelsa*, *B. lutea*, *B. papyracea*, *B. populifolia*, and *B. rubra* require the same treatment. The young plants will not be fit to go out into nursery lines until the end of the second season. The following is perhaps the surest and simplest method of establishing a birch nursery wherever it is practicable :—Select a piece of ground, say one acre in extent, surrounded on all sides (if possible) by a few fine mature birch-trees. Clean and cultivate this thoroughly in summer, and sow in early autumn a crop of rye or winter oats. In winter, should there be a heavy fall of snow, sow about 20 or 30 lbs. of birch seed on the surface of the snow: the melting of the latter will settle the seed firmly and naturally in the soil. During the spring and summer following, the rye or oats will afford protection and shelter to the tender young birch plants, and by the time the crop is out they will be able to take care of themselves. At the end of the following year they will be ready for transplanting into the nursery.

12. *Carpinus betulus*, the Hornbeam, is a native of Britain. Its height varies from 30 to 40 feet. Many recommend autumn sowing for this species so soon as the seeds are gathered, but I prefer to stratify them in river sand in the open throughout the winter, and to sow early in the following March. The heaps must not be raised too high (six or eight inches), and the seed should be turned over from time to time. Unless so treated the seeds do not come up for fully twelve months.

The hornbeam is a very useful tree, both for cultivation as a nurse with oak or other trees, and for coppice. Though never becoming a tree of first-class dimensions, its wood is of considerable value, and it comes away freely in very poor soils. For planting as a hedge it is invaluable. It is not, however, a very fast grower. The seeds should be sown like those of *Acer campestre*. The young plants may be transplanted into nursery lines at the end of the first season's growth.

13. *Carya alba*, the White Hickory, is a native of the United States. Its height is 50 feet.

This is one of a handsome and valuable group of forest trees. It is very hardy, of rapid growth, and it yields timber of great value. It is deserving of extensive cultivation in our woods, and should be planted, as suggested for *Abies Douglasii* and some others, at intervals of twenty feet, with hornbeam, larch, or other suitable trees as nurses. The seeds may be sown like those of the horse-chestnut, and they should be kept stratified through the winter in dry sand under cover. The seedlings must be transplanted at the end of the first year, and the previous cutting of the tap-roots *in situ* by means of a spade is to be recommended, although the roots are by no means so formidable as those of *Juglans nigra.*

14. *Carya amara*, the Bitternut Hickory, is a native of the United States. Its height is 50 feet. It should be treated like *C. alba.*

15. *Carya porcina*, Pignut Hickory, is a native of the United States. Its height varies from 50 to 60 feet. Other equally valuable varieties may be found in *C. sulcata*, *C. tomentosa*, and the like. Many of the trees are as highly esteemed in America for the sake of their nuts as on account of their timber.

16. *Castanea vesca*, the Sweet or Spanish Chestnut, is said by some to be a native of Britain, but this is doubtful. The better-fruited varieties come from Southern Europe. In the Cevennes they constitute the staple food of a numerous population. Their height is 80 feet. The seeds are treated precisely in the same manner, and sown at the same time, as those of the horse-chestnut; but, as they are very prone to germinate too soon, especially in mild winters, they should be kept in a cold place. The seedlings should be transplanted into nursery lines at the end of the first season.

17. *Cerasus avium*, the Common Bird-Cherry, is a native of Britain. Its height is 40 feet. It is a valuable tree, both as an ornament and on account of its timber, when well grown. The seeds should be stratified in sand throughout the winter, and should be sown when germination commences in early spring in the same manner as those of *Gleditschia triacanthus.*

The seedlings may be transplanted, if they have made good growth, at the end of the first season.

18. *Cytisus laburnum*, the Common Laburnum, is a native of Switzerland. Its height is 25 feet.

This tree is esteemed for its ornamental qualities, though Dr. Brown states that he has sold the timber of large specimens at 7s. per cubic foot. He specially recommends the cultivation of the Scots laburnum (*C. alpina*). The seeds should be sown in the same manner as those of *Robinia pseudo-acacia*, and they should be transplanted after the first season's growth.

19. *Fagus sylvatica*, the Common Beech, is a native of Britain. Its height is 100 feet. Dr. Brown recommends the sowing of this in the rough manner prescribed for the oak and chestnut; but I incline to the opinion of M. Bagneris, that its seed requires some care, as the success of the tree will depend on the strength and vigour of the seedling. The seeds should be stratified during the winter months in sand, and they should not be sown before the middle of March, if they can be prevented from germinating so long. They may be sown in beds in wide drills as recommended for *Gleditschia*, and the young plants should be shaded so soon as they begin to appear above ground. The seedlings may also be raised in the manner recommended by M. Bagneris, which has been already described. If well grown, they may be transplanted at the end of the first season.

20. *Fraxinus excelsior*, the Common Ash, is a native of Britain. Its height is 80 feet.

As the seeds of this tree do not germinate readily, they should, when gathered or bought, be stratified in sand in the same manner as those of the hornbeam. They may be sown like those of *Acer pseudo-platanus*, only somewhat more thinly, about the end of March. The seedlings are subject to damage by spring frosts when they first shoot up, and may be transplanted during the first season.

21. *Gleditschia inermis* is a thornless variety of *G. triacanthus*, and should be treated in a similar way.

22. *Gleditschia triacanthus*, Christ's Thorn Locust-tree, is a hardy and fast-growing tree, but it is ornamental rather than

useful. The seeds should be sown in wide drills made with the *ratissoire,* and they should be placed in a quincunx manner in the drills. In consequence of their hard outer covering, they may with advantage be steeped previous to sowing. The seed should be covered to a depth of three-quarters of an inch.

Like all leguminous plants, the tender stems of the seedlings are very susceptible of injury by frost, and as their subsequent growth is very rapid, they need not be sown until the middle or end of April. In the event of late frosts they should receive protection. They should be transplanted during the first season.

23. *Gymnocladus Canadensis,* the Kentucky Coffee-tree, is a native of Canada and the United States. It may be sown as above, but the seeds should be placed a little further apart, and covered to a depth of one inch. They do not make much upward growth during the first year, and transplantation may be effected then or at the end of the second season.

24. *Juglans cinerea,* the Butternut, is a native of the United States. Its height is 60 feet. It is a handsome, hardy, fast-growing tree, and is much esteemed in America for the sake of its "nuts." It requires the same treatment as *J. nigra.* Its tap-root, however, is not so difficult to deal with, but should still receive an autumnal cutting *in situ.*

25. *Juglans nigra,* the Black Walnut, is a native of America. Its height is 80 feet, and it is perhaps the most valuable addition that has been made to our list of forest trees. Its rapidity of growth is unparalleled among the forest trees of temperate climates, and is fully equalled by the value of its timber. If sown in the nursery it should receive the same treatment as the horse-chestnut. In my opinion, however, in order to get the best results, or rather to do it justice, the "nuts" should be sown *in situ* in circular pits, eighteen inches deep and the same in width, the pits being made forty feet apart. If raised in a nursery, its enormous tap-root has to be cut heavily; and this, added to the shock of transplantation, greatly retards, if indeed it does not destroy, the growth of the tree. To save the uncertainty that might arise in the case of bad seeds, they may be allowed to germinate previous to being sown. In such cases they may be put out while the radicle varies from one to

three or four inches in length. In this way, too, several years of growth will be gained, and a better development will be secured. In my opinion, all the Caryas would succeed better if treated in the same manner.

26. *Juglans regia,* the Common Walnut, is a native of Persia. Its height is 80 feet. It is seldom planted as a forest tree, but requires the same treatment as the foregoing.

27. *Liriodendron tulipifera,* the Tulip-tree, is a native of the United States and Canada. Its height is 90 feet. It is a singularly handsome and hardy tree, of very quick growth, and one that well deserves to be cultivated more than it is. The timber, however, is of questionable value. The seeds should be obtained as soon as possible after ripening, and they should be stratified in the open in the same manner as those of the ash. They may be sown like those of the Norway maple. On their first coming up the young plants are somewhat tender, and need shading from frost and sun. They may be transplanted into nursery lines at the end of the first season.

28. *Platanus occidentalis,* the Western Plane, is a native of the United States. Its height is 80 feet. According to Dr. Brown, it is less spreading and more rapid in growth than the Eastern plane, but is treated in the same way.

29. *Platanus orientalis,* the Eastern Plane, is a native of the Levant. Its height is 80 feet, but in France it grows still higher. It is generally raised from cuttings,[1] but it is also readily raised from seed, which should be sown in precisely the same manner, and receive the same treatment as that of the alder. The surface of the soil must be kept fresh, and be protected from frost and sun. If well grown, the seedlings may be transplanted into nursery lines at the end of the year, but they will require some light covering during the first winter. The seeds should be sown early in April, in a light, rich soil.

30. *Populus acladesca,* the Black Italian Poplar, is a native of Italy. Its height is 100 feet. Dr. Brown speaks very highly of this species, and it is that chiefly cultivated in Southern and Central France. Its treatment is the same as that of *P. nigra.*

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[1] A full description of this process is given under the heading of *Populus nigra.*

31. *Populus alba*, the White or Abele Poplar, is a native of Britain. Its height varies from 80 to 100 feet. It is especially an ornamental tree, and may be propagated like *Populus nigra*.

32. *Populus Canadensis* is a native of Canada. Its height is 70 feet and upwards. This is a variety of great value, and should be cultivated to a much greater extent than it is. It may be propagated like *P. nigra*.

33. *Populus canescens*, the Grey Poplar, is a native of Britain. Its height is 60 feet. It closely resembles *P. alba*, and its propagation is the same.

34. *Populus fastigiata*, the Lombardy Poplar, is probably a native of Northern Italy, but it has been long acclimatised in Britain. Its height is 60 feet. This well-known pyramidal variety hardly needs much description. It is of little value as a forest tree, but it may be propagated in the same manner as the other species of *Populus*.

35. *Populus macrophylla* or *Ontariensis* (Vilmorin), the Ontario Poplar, is a native of Canada. Its height is 100 feet. Dr. Brown recommends this species very strongly as a timber tree, especially for river banks, where the soil is shallow. Where shoots are procurable, it may be raised in the same manner as *P. nigra*; but, like *P. Canadensis*, it may be obtained more readily from seed, which should be treated like that of the alder and plane. Of course, in the latter case, a longer time must elapse before the seedlings are ready to be planted out.

36. *Populus nigra*, the Common Black Poplar, is a native of Britain. Its height varies from 80 to 100 feet.

This species is chiefly cultivated as a forest tree in England, and in most parts of France. Poplars seldom do well save in moist, low-lying situations, and in soils that contain a good percentage of lime. They are most readily propagated by cuttings. These should be taken from vigorous, well-ripened shoots of the previous season's growth, and should have at their base three or four inches of two-year-old wood. The most convenient length for the cuttings is one foot, and they should be inserted so as to leave but two "eyes" above ground. Both buds are allowed to push, but when one has clearly taken the lead, the other is cut away close to the stem. If the seedlings are to be lifted during the first season, they may be set six inches apart in the rows, which should be eighteen inches apart; but if, as is more advisable, they are to stand for two years, the rows should be two or two and a half feet apart, and the plants twenty-eight inches or two feet distant from each other. The more space they are allowed the better will be their growth, while their roots will be less likely to be injured when they are taken up. All the poplars may be propagated by layers, but there are seldom facilities for managing this save in large establishments.

37. *Populus tremula*, the Aspen, is a native of Britain. Its height is 70 feet. It is a very beautiful and by no means valueless tree, either as a nurse or for the sake of its wood. It is also a rapid grower. It is doubtless as easy of propagation as any of the others, and it requires the same treatment.

38. *Quercus alba*, the White Oak, is a native of the United States. Its height is 80 feet. Dr. Brown recommends this as a forest tree, both on account of its growth and the value of its timber. The following species are much more in favour on the Continent. All the oaks may be treated in the same manner as *Q. pedunculata.*

39. *Quercus Bannisteri* is a native of the United States. Its height is 15 feet. This little species is of importance, not from its value as a forest tree, but from its hardiness, its utter indifference as to soil, and from the fact that it affords excellent cover wherever game is preserved.[1] It ripens its crop twice in the season, and fruits every year from a very early age (four or five years) in astonishing abundance. Its acorns are small, yellow-fleshed, and greedily devoured by birds of all kinds, which disseminate them far and wide. It grows freely in the worst soils, and is specially adapted for the wooding of the driest hillsides, where its permanence is assured by the number of acorns it produces every year. Its seeds should be covered to a depth of three-quarters of an inch.

40. *Quercus catesbæi* is a native of the United States. Its height is uncertain. It is a handsome species, with highly ornamental foliage. The Barres Catalogue states that it may

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[1] According to the Report of the Domaine Forestier at Barres Vilmorin, it forms, when planted pretty close, an almost impenetrable cover.

readily be distinguished in its first growth by the fact that it sends out, close to the ground, three or four leaves, without at first any trace of a stem.

41. *Quercus cerris*, the Turkey Oak, is a native of Southern Europe. Its height is 100 feet. It is a very charming and useful timber tree, quite hardy, and not nearly so much valued as it should be. Its timber is in no way inferior to that of the common oak, its growth is more rapid, and it is best suited to those dry and somewhat sandy soils in which the latter is seldom found to thrive. The seed, however, is not always easily procured.

42. *Quercus coccinéa*, the Scarlet Oak, is a native of the United States. Its height varies from 80 to 90 feet This species, apart from the great beauty of its foliage, which becomes bright crimson in autumn, has the advantage of being a very fast grower, but its wood is of second-class quality. Nevertheless it has many characteristics to recommend it as well adapted for general cultivation, and from no plantation in which the soil is suitable should it be left out.

43. *Quercus olivæformis* is a very elegant and graceful species, and its growth is as rapid as that of *Q. palustris.* Its habit, however, is closer and more pyramidal. The acorn is small, and almost entirely covered in by the cup, which somewhat resembles in appearance the rough spiked capsule of the sweet chestnut. It thrives wonderfully in Brittany, where the soil and climate seem peculiarly adapted to its requirements.

44. *Quercus palustris*, the Swamp Oak, is a native of the United States. Its height is 70 feet. It is perhaps both the most beautiful and valuable of all the American oaks, and it is an exceedingly fast grower. While young it has a graceful pendulous habit, straightening as it grows up. Its elegantly laciniated leaves turn deep purplish red in autumn, and when they are all planted together form a beautiful contrast to the bright crimson hue of *Q. coccinea*, the more sober russet of *Q. rubra*, and the golden tints of *Q. tinctoria*. It is best suited, as its name implies, for moist, fresh soils ; at the same time, it can make astonishing growth in the dry sands of the Sologne. It is now receiving considerable attention as a forest tree both in France and Germany, and as the value of

exotic timber-trees becomes better realised, it will doubtless receive equal attention in England. As the acorns are very small, it may be sown in the same manner as *Q. Bannisteri.*

45. *Quercus pedunculata*, the Common Oak, is a native of Britain.

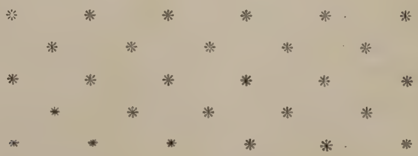
46. *Quercus sessiliflora*, the Sessile-flowered Oak, is a native of Britain. Its height is 80 feet.

For simplicity and convenience these two varieties of the common oak may be considered together. Their respective peculiarities are well described by M. Bagneris as follows :—

" These two trees inhabit mild and temperate climates, the former advancing further north, the other more towards the south, but their habitat is chiefly determined by the amount of moisture in the soil. Thus the former prefers moist and damp soils containing a rather strong proportion of clay, the latter free soils that are merely moist. The former is chiefly found in plains ; the latter, though also found in plains, prefers hilly or low mountainous ground."

They are most easily distinguished from one another by the fact that the sessile-flowered oak has pedunculate leaves, while the other bears pedunculate flowers and sessile leaves.

The most satisfactory method of sowing acorns is in trenches, as in the case of the horse-chestnut, walnut, and others. The trench is made by stretching a line across the part of the ground to be operated on. Along this line the soil is removed with a shovel to the depth of one or two inches, according to the size of the acorns. These are now laid down in the form of a double quincunx, thus :—



Each acorn is allowed from six to eight square inches of space, and in this way the centre lines are hardly inferior to those on the outside. The breadth of the shovel is allowed between the trenches, and the earth taken out in the formation of the second trench is employed to fill up the former one that has been already sown. As young oak seedlings are very liable to be injured by spring frosts, they should never be sown before March. The acorns should be kept stratified in dry sand or charcoal, under cover, in a cool (but frost-proof) place throughout the winter.

47. *Quercus rubra*, the Red Oak, is a native of the United States. Its height is 70 feet.

This is a decidedly valuable tree, and it is specially adapted for forest culture. It is of very quick growth. The Barres Catalogue states that it succeeds there better than any other species. The timber is of moderate quality, but it is superior to our second-class woods. Birds and other animals are very fond of its acorns.

48. *Quercus tinctoria*, the Quercitron Oak, is a native of the United States. Its height varies from 70 to 80 feet. It is a very ornamental fast-growing species, but its wood is of doubtful value. Other handsome and by no means useless varieties may be found in *Q. aquatica*, *Q. castanefolia*, *Q. falcata*, *Q. lyrata*, *Q. phellos*, *Q. prinus bicolor*, and many others.

There is a very beautiful and curious group of oaks that come from Japan, but they are too tender for our climate.

49. *Robinia pseudo-acacia*, the Common Acacia, is a native of Canada and the United States. Its height is 80 feet. It is a tree that is far more in demand and more extensively cultivated in France than in England, despite the many useful purposes to which its produce can be put, and the lasting nature of its wood. Nothing can surpass it for outdoor fencing or for setting in the ground. It is one of the fastest-growing trees we have, especially if planted in a fresh, free, light rich loam. Though it may do fairly well, it is not at its best in poor dry soils. Its seeds are sown in beds, in wide drills made by the *ratissoire*, in quincunx fashion, at least four square inches being allowed to each seed. Being subject to frost at the time of germination, it should not be sown before the middle of April.

50. *Saphora Japonica* is a native of Japan. Its height varies from 40 to 50 feet. It is very ornamental, and a fast grower, but of no value as a forest tree. There is a weeping variety, *S. pendula*. It should be treated like *Gleditschia*.

51. *Tilia Europea*, the Common Lime-tree, is a native of

Britain. Its height varies from 80 to 100 feet. This and its varieties are generally propagated by layers. It is of little value to the forester, but useful as an ornamental tree, notably the variety *T. rubra.* For layering, the stems must be cut over close to the ground, and suckers allowed to spring up from these. At the end of the season's growth these should receive an incision on the under side at the base, and on being pegged down, the soil should be heaped up for them to strike in. At the end of the second season they may be taken up and set in nursery lines. I have no doubt that if an incision were made at every internode, and the whole shoot laid down, every bud would give a plant.

52. *Ulmus campestris,* the Common Elm, is a native of Britain. Its height is 80 feet. Its seeds should be sown like those of the alder, but somewhat more space should be allowed. Most authorities recommend sowing in July, so soon as the seed is ripe, as it is said to keep very badly; but I have succeeded with spring sowings. The seedlings will transplant at the end of the first season.

53. *Ulmus montana,* the Wych Elm, is a native of Britain. Its height is 100 feet, and it must be treated like *U. campestris.*

The following among other shrubs are employed by the forester for making hedges: the Whitethorn, Privet, Holly, Laurel, and in game coverts, *Berberis vulgaris* and *Mahonia aquifolia.*

Although there are many other ornamental and fruit-bearing shrubs and plants, they cannot be included under the heading of legitimate Forestry. The seeds of all the above require to be stratified in the open in sand for at least twelve months, like *Carpinus betulus,* and to be similarly sown during the following spring. *Berberis* and *Cerasus Laurocerasus* are very impatient of frost when they first come up.

TRANSPLANTATION, ETC.

As has been previously stated, a sufficient, but not excessive, supply of moisture is essential for germination; and therefore, more especially in the case of fine soils that have been but lightly covered, the surface must never be allowed to become so dry as to check this process. This is seldom likely to occur in soils that have been properly prepared, or in sowings that have not been deferred until too late in the season. At the same time, such a state of things does occasionally happen, and the loss sustained if the tender young radicle is allowed to dry up before it has had time to reach a fresh stratum will be very serious. In cases where such issues are expected, frequent waterings should be given until such time as the seedlings begin to show well above ground. Sometimes the young plants will need protection against frost and sun, but generally they can now hold their own, at any rate until the severe summer and autumn heats set in, and they will be all the stronger and hardier if they can do so.

No small proportion (beech, spruce, and other Abies as well as Piceas, larch, and cupressus) will at this time, when the young stem between the cotyledonary leaves and the ground is in its tenderest stage, require the use of some light temporary shading to protect them from late frosts, and in the climate of Sologne, from the scorching heat of the sun also. Many plants that are perfectly hardy a little later on, when their watery tissues have become somewhat consolidated, are in their infancy as tender as greenhouse plants.

It is not our practice to shade at the outset any of our hardier pines, and the more delicate ones seldom push before all further fear of frost is over; the same being the case with the leguminous plants.

For the purpose of shading Dr. Brown recommends the laying of spruce branches over the beds; but lighter materials, such as broom, or heather, when laid directly on the beds, are open to serious objection, inasmuch as they have a tendency to "draw" those plants that they do not crush, and besides being less easy to manipulate, they last but a short time.

M. Bagneris is of opinion that "twigs laid flat on the ground or stuck in between the trenches answer well. It is, above all, shelter rather than cover that is needed, and consequently the nurseryman will avoid the constant use of thatch supported horizontally at a certain height on pegs. Broom, furze, and branches of the Conifers are very convenient for this purpose."

In the climate of Sologne, however, the horizontal shading supported over the beds is the safer course. A light trellis-work should be laid on low forked sticks (say two feet high), and this should be interlaced with the materials used for shading, namely, broom and heather. For material to lay on the beds, fern is decidedly the best. The cover should not be so heavy as to impede the action of light or the fall of rain, merely enough to check the force of the sun's direct rays, and to counteract the full effect of late spring frosts. Permanent framework, of suitable lengths and breadths, and lightly interwoven with heather, will be found very handy, and when out of use it can be set up so as to occupy little space. In the Sologne the shading has to be kept up until the end of August or middle of September; but in England plants that have attained a fair degree of growth and strength should have little to fear from the sun's rays.

In cases where seeds have been sown too thickly, the thinning out of some of them may become a necessity, and should be done as soon as the plants can be readily handled. This will prevent the seedlings from becoming weakly or drawn, but it should not be necessary if care is exercised in sowing.

The surface of the ground, from the moment the young plants are well up, should be kept scrupulously clean, and frequently stirred so as to give full play to weather influence. Nearly all our weedings here, and those in the beautifully-kept nurseries of the Forest Department at Salbris, are accomplished with the small thrust-hoe that was employed to make the drills, and it is astonishing how quickly, safely, and economically the work can be got through by means of this little tool.

With regard to further waterings, in the case of hardy forest plants, it must be sparingly resorted to, "unless it can be effected with a force-pump, whose spout is furnished with a rose," and the spray allowed to fall from a height. As this proceeding, however, is a costly one, it should be avoided as much as possible. It is to be noted that although the plants are stationary for a short period in summer, they will shoot up afterwards with all the more vigour, and soon make up their lost ground. When, however, they are distinctly seen to flag, which is rarely the case in well-prepared soil, watering must be resorted to, and to be of any use it must be done thoroughly, and kept up until a change occurs. No mere sprinkling will suffice. As a rule, when one begins to water established plants, it must be continued until a sufficient fall of rain comes.

The seedlings now require no further special attention until they have reached the end of their first season's growth, when the majority will be ready to be transplanted into nursery lines, or planted out permanently. The object of this transplantation is for the purpose of encouraging the formation of fibrous rootlets, without which many species cannot be finally transplanted with safety.

A considerable portion of the nursery should be set aside for this purpose, and temporarily cultivated with potatoes, buckwheat, or other similar crop. On the removal of the crop, the ground must be kept free from weeds, and it then only requires to be thoroughly forked over to be in readiness for the purpose in hand. Should it not be required during the autumn, it ought to be rough-ridged, in order to be thoroughly exposed to atmospheric influence during the winter months.

It is by no means agreed whether autumn transplantation is or is not preferable to transplantation during spring, but the former is probably the better, provided that the winter should not be one of undue severity. M. Bagneris's remarks on this point are well worthy of notice:—

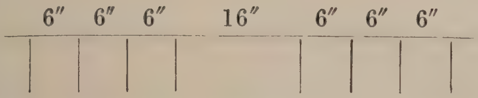
"Except in the case of planting out in sods (like turf), in which the roots remain entire, it is undeniable that the operation ought to be done while vegetation is still active. . . . There is, therefore, no choice left but between autumn and early spring. If it be remembered that the welfare of plants depends on the state of the roots, it is at once seen that autumn is to be preferred to spring. . . . Moreover, in the case of somewhat old seedlings, the alternation of frost and rain, which characterises the season of the close of vegetation, produces complete contact between the roots and soil. But, on the other hand, when seedlings are put out quite young, frost, by causing the soil to expand, compels them to follow the upward movement, and, when thaw sets in, the young plants run the danger of having their roots laid bare. It cannot, therefore, be laid down as an invariable dictum that autumn is preferable to spring, or *vice versa.* The question is entirely one of local conditions. . . . *The essential thing is to plant carefully.*"

As a rule, considering both the relative advantages, and the pressure that may arise by limiting the execution of so important a work to a given short period, which is liable to frequent interruption on account of the state of the weather, the work may be divided between the two seasons, the larger and more vigorous seedlings being transplanted in autumn, and those whose success seems less certain in spring. It is, however, to be carefully borne in mind that the smaller the seedling, so long as it is healthy and well furnished with fibrous roots, the greater the chance of its being transplanted with safety.

The taking up and storing of the seedlings previous to transplantation requires the utmost care. Injury to the upper parts is, of course, hurtful; but in no degree so much so as injury to the tender young roots. The best tool for the purpose is a stout five-pronged fork set in a long handle. This should be inserted three or four inches outside the first line of plants, and thrust straight down, so as to lift up the plants with the clods attached. The seedlings should then be carefully separated by the hand. Yet, however carefully this operation may be performed, and however well the soil may have been prepared, some of the roots must sustain injury to a certain extent, and all broken or abraded parts should be removed by a clean downward cut with a sharp knife. The plants may now be removed to the upper end of the transplantation ground, or to an adjoining vacant square, and a trench having been opened with a spade, they should be laid carefully and thinly against its sloping side, and their roots should be at once covered with fine soil. From these trenches they can be taken up as required by the transplanters.

The following treatment is given to the Scots pine seedlings in transplantation :—

The ground to be planted is dug, and its surface is raked fine all over. The beds into which the seedlings are to be transplanted are marked out by a wooden rake, set in a long handle, the teeth being of wood, and arranged at intervals of six inches—sixteen inches in the centre being devoid of teeth—thus:—



A cord is stretched across the outer lower edge of the square, and the lines for the plants are traced by means of this rake, each bed of three feet eight inches in width containing six lines of plants, and the paths between the beds being one foot wide. The instrument used in transplanting is a common *plantoir* or dibble, about fifteen inches in length, an inch and a half in diameter, and shod with iron over the lower six inches of its length. The plants being held with the left hand, a hole is made by the dibble held in the right; the plant is inserted, and a sharp side turn to the left with the dibble in making the next hole firms the seedling already planted, and prepares for the reception of the second. Skilled workmen will readily transplant from 10,000 to 12,000 seedlings in one day, and for this they receive 4d. per 1000.

The distance between the lines, and between the plants in the lines, depends on the time they are to be allowed to remain in the nursery. If they are to be planted out, as is usually the case in France, in the autumn or spring following, twenty-five seedlings are allowed to the metre; six inches is allowed between the lines.

If they are to remain without a second transplantation for two or even three years in the same lines, the distance between the plants must be increased to six inches or a foot, and that between the lines from one to two feet.

All varieties of Abies, Picea, *Pinus strobus,* and birch, require to remain two years in the seed-beds previous to transplantation, although occasionally very fine specimens may be moved after the first year.

Pinus sylvestris, P. laricio, P. Austriaca, P. pindensa, P. rigida, and others of similar habit, may go out at the end of the first season, and so may the alder and laburnum among deciduous trees.

In the case of tap-rooting plants, it is necessary, for purposes of transplantation, to check the development of the tap-root, and to encourage that of lateral fibrous rootlets—a work which is especially necessary in such seedlings as *Pinus picea, P. sabiniana,* and some leguminous plants, where very few lateral rootlets are formed.

The difficulty, according to M. Bagneris, "is remedied, when the seedlings are not removed into nursery lines, by cutting off the tap-root *in situ* underground. For this purpose a spade is employed, the blade of which is flat and twenty inches long, terminates in an oblique edge, and makes a certain angle with the handle. The instrument ought to be strong, sharp, and of good steel. The seedlings having been sown in narrow trenches, the spade is pushed into the ground on either side of each trench, so as to cut off a portion of the roots of every plant. The notches made by the instrument are pressed down by the foot. The operation is generally performed in the autumn of the first year, and from the very commencement of spring numbers of lateral roots are observed to develop all round the section.

This course of treatment will apply in the instances noted above, and among deciduous trees to Walnuts, Caryas, Oaks, and Beeches, that have not been transplanted during the first season. Some species, although they attain during their first season too great dimensions to be transplanted with the dibble, have not such excessive root development as tap-rooting seedlings, and only need to be taken up carefully to insure their safe removal. Among these, *Pinus Coulteri, P. insignis, P. Salisburya, P. adiantifolia, Taxodium distichum,* Cedars, etc., and among deciduous trees, Chestnuts, Horse Chestnuts, Maples, *Robinia,* etc., may be noted.

In order to commence the work of transplanting, a cord is stretched across the bed, and a trench is formed to a depth of about twelve inches. The lower wall of the trench must be kept straight and solid, so that the plants can be set upright against it. In the case of roots so long as to require a greater depth, a further section may be cut, by first inserting the spade vertically to a sufficient depth at the back of the trench, and then lifting out the soil by a sloping spit from the upper side. The plants after having been taken up, and after getting their tap-roots shortened if necessary, and all injured or broken roots cut clean, should be laid upright against the wall of the trench with the left hand, while with the right a few handfuls of light soil should be brought forward to keep them in their place. When all are laid in, the trench may be refilled with the broken soil, and firmed gently round the plants with the foot. They should not be buried high above the collar, but only sufficiently to allow for subsidence. The same operation is repeated in subsequent trenches.

For seedlings that are only to remain one year in the nursery, they may be placed at intervals varying from four to six inches in the lines, which should be from one foot to eighteen inches apart. When they are intended to attain any size before planting out, greater distances must be allowed, according to their growth. The same method will apply to Abies, Piceas, etc., when transplanted a second time.

Some, instead of transplanting by means of a trench, employ a specially constructed pick-hoe, and with this tool the work may be done with equal safety.

In the case of the transplantation of more advanced seedlings, pits of a suitable size for their reception must be prepared. The plants must be lifted carefully with the ball of earth intact, and all broken or protruding roots cleanly cut back.

The operation of *recepage*, or cutting back of certain young forest trees, with a view to the promotion of the growth of a clean, straight, upright stem, is generally performed when the trees are well established in their permanent site.

Since the production of a heavy crop of vigorous seedlings must exert a heavy drain on the soil, more especially with regard to the mineral constituents it contains, and since a sufficient degree of fertility cannot be maintained unless these lost elements are restored, the work of manuring, which may not have been required at the outset, becomes necessary. It is not our practice to resort to farmyard manure by itself, but rather to make it the basis of a valuable compost. Thus the scourings of old ditches, decayed leaves, weeds, refuse of all sorts, mixed with lime in greater or less proportions, as it may be intended to apply it to deciduous trees or Coniferæ, are mixed up with the farmyard manure in layers, and a coating of turfy loam is laid over the top. These heaps are prepared in the spring, and turned over at intervals two or three times until the whole mass is thoroughly incorporated. Thus, when the time of application arrives, a fine rich mould of high fertilising power is obtained.

WEIGHTS OF FOREST-TREE SEEDS.

By the kind permission of the editor of *Forestry*, the following table, showing the number of forest-tree seeds in a given weight, which appeared in the numbers of that Journal for July and October 1883, is appended. The table may be found of service in regulating orders for supplies of seed. In those columns which are left blank (*e.g.*, alder, birch, planes, poplars, elms), the seeds have, as a rule, been too numerous and light to enable me to determine accurately their weight with the means at my disposal; and in a few cases I have omitted to weigh the seeds of the varieties named :—

1 Ounce = 28⅓ Grammes.
1 Kilogramme = 2⅕ lbs. Avoirdupois.
50 Kilos. = 1 Cwt.
1000 Kilos. = 1 Ton.

Botanical Name.	English Equivalent.	Number of Seeds per		
		Gramme.	Ounce.	Pound.
Abies alba	White Spruce	340	9,633	154,528
,, Canadensis	Hemlock ,,	400	11,333	181,328
,, Douglasii	Douglas Fir	110	3,116	49,856
,, excelsa	Common Spruce	152	4,306	68,896
,, Menziesii	...	1000	28,333	453,328
,, Mertensiana	...	400	11,333	181,328
,, Morinda	...	55	1,558	24,928
,, nigra	Black Spruce	...	...	...
,, orientalis	Eastern ,,	160	4,533	72,528
Cedrus Atlantica	Mt. Atlas Cedar	24	481	7,696
,, deodara	Deodar ,,	...	...	...
,, Libani	Lebanon ,,	24	680	10,880
Cupressus Lawsoniana	Lawson's Cypress	290	8,216	131,456
,, macrocarpa	...	...	...	...
Juniperus Virginiana	Virginia Red Cedar	50	1,416	22,656
Larix Europæa	Common Larch	150	4,250	68,000

WEIGHTS OF FOREST-TREE SEEDS—*continued.*

Botanical Name.	English Equivalent.	Number of Seeds per Gramme.	Ounce.	Pound.
Picea amabilis	The Lovely Silver Fir	12	340	5,440
,, balsamea	Balm of Gilead ,,	157	4,448	71,168
,, bracteata	...	...	...	...
,, Cephalonica	...	20	566	9,056
,, concolor	...	75	2,125	34,000
,, grandis	...	52	1,470	23,520
,, lasiocarpa	...	50	1,416	22,456
,, nobilis	...	20	566	9,056
,, Nordmanniana	...	22	623	9,968
,, Pindrow	...	24	680	10,880
,, pinsapo	...	24	680	10,880
,, pectinata	Common Silver Fir	33	935	14,960
,, Regina Amelia	...	20	566	9,056
Pinus Austriaca	Austrian Pine	68	1,926	30,816
,, Benthamiana	...	14	396	4,336
Pinus Coulteri	...	3	85	1,360
,, excelsa	...	24	680	10,880
,, insignis	...	44	1,246	19,936
,, Jeffreyana	...	20	556	9,056
,, Lambertiana	...	$4\frac{1}{2}$	127	2,032
,, laricio Calabriæ	Calabrian Laricio	96	2,720	43,520
,, ,, Corsicæ	Corsican ,,	91	2,578	41,248
,, Monspessulana	Montpellier Pine	...	...	...
,, Pallasiana	...	...	...	...
,, Parryana	...	...	...	...
,, Peuce	...	27	765	12,240
,, ponderosa	...	22	623	9,968
,, resinosa	...	...	...	...
,, rigida	Pitch Pine	181	5,128	82,048
,, Sabiniana	...	$1\frac{1}{10}$	30	488
,, strobus	Weymouth Pine	70	1,983	31,728
,, sylvestris	Scots ,,	200	5,666	90,656
Salisburya adiantifolia	Maiden-Hair Tree	$\frac{3}{5}$	17	272
Sequoia gigantea	Wellingtonia	315	8,925	143,800
,, sempervirens	...	200	5,666	90,656
Taxodium distichum	Louisiana Cypress	19	538	8,608
Thuja gigantea	...	...	...	...
,, Lobbii	...	...	...	...
,, orientalis	...	84	2,380	38,080
Acer campestre	The Common Maple	...	...	...
,, negundo	...	28	793	12,688
,, Pennsylvanicum	Pennsylvania Maple	30	850	13,600
,, platanoides	Norway ,,	10	289	4,624
,, pseudo-platanus,	Sycamore ,,	10	289	4,624
,, rubrum	Red ,,	70	1,980	31,680
,, sempervirens	Sugar ,,	32	900	14,400
Alnus glutinosa	Common Alder	...	...	...
,, incana	Grey ,,	...	...	...
Æsculus hippocastanum	Horse Chestnut	...	...	36
Betula alba	Common Birch	...	...	...
Carpinus betulus	Hornbeam	22	623	9,968
Carya alba	White Hickory	...	6	109
,, amara	Bitternut ,,	...	9	144

WEIGHTS OF FOREST-TREE SEEDS—*continued.*

Botanical Name.	English Equivalent.	Number of Seeds per		
		Gramme.	Ounce.	Pound.
Carya porcina	Pignut Hickory	...	9	144
Castanea vesca	Sweet Chestnut	...	...	...
Cytisus laburnum	Laburnum	47	1,321	21,336
Cerasus avium	Bird Cherry	3½	97	1,552
Fagus sylvatica	Beech	6	170	2,720
Fraxinus excelsior	Ash	15	425	6,800
Gleditschia inermis	Locust Tree	6	170	2,720
,, triacanthus	,,	4½	127	1,932
Gymnocladus Canadensis	Kentucky Coffee Tree	...	19	304
Juglans cinerea	Butternut	...	...	38
,, nigra	Black Walnut	...	...	20
,, regia	Common ,,	...	...	...
Liriodendron tulipifera	Tulip Tree	28	793	13,688
Platanus occidentalis	Western Plane	...	...	...
,, orientalis	Eastern ,,	...	...	...
Populus acladesca	Black Italian Poplar	...	...	...
,, alba	White ,,	...	...	...
,, Canadensis	Canada Poplar	...	...	...
,, canescens	Grey ,,	...	...	...
,, fastigiata	Lombardy ,,	...	...	...
,, macrophylla	Ontario ,,	...	...	...
,, nigra	Black ,,	...	...	...
,, tremula	The Aspen	...	...	...
Quercus alba	The White Oak	...	...	...
,, Bannisteri	Bannister's ,,	...	26	414
,, Catesbæi	Catesby's ,,	...	...	...
,, cerris	Turkey ,,	...	...	...
,, coccinea	Scarlet ,,	...	16	261
,, palustris	Swamp ,,	...	26	414
,, olivæformis	,,	...	...	...
,, pedunculata	Common ,,	...	...	99
,, rubra	Red ,,	...	8	135
,, tinctoria	Quercitron ,,	...	9	144
Robinia pseudo-acacia	Common Acacia	58	1,643	26,288
Saphora Japonica	...	12	340	5,440
Tilia Europæa	Lime	...	...	...
Ulmus campestris	Common Elm	...	...	...
,, montana	Wych ,,	...	...	...

NOTE.—Plans of the author's Forest-Tree Nurseries are given as Plates II., III., and IV.

II.

THE FORMATION AND MANAGEMENT OF FOREST-TREE NURSERIES.

By Thomas Berwick, *St. Andrews.*

From economic and agricultural points of view, as well as from climatic and æsthetic considerations, the raising of forest trees is all-important; since, moreover, the home demand for timber of all kinds may be expected to increase, as the supplies from America and Northern Europe cannot always continue, the practice of raising forest trees in nurseries has become general in the present century, and many millions of seedlings are now annually produced.

Nurseries are met with in different soils and at different altitudes. *In fixing a site*, open land, with a northerly and southerly exposure—many forest-tree nurseries being formed on flat ground—with or without inclination, and so situated as to afford free circulation, is generally considered best.

The nursery should, if possible, embrace a variety of soils. The normal loams, consisting of sand and clay, rich alluvial loam, which is very suitable for the raising of larch seedlings, the humus soils containing vegetable matter, and peaty land, with a proportion of sand, might be set down as the best. Too clayey, retentive ground should be avoided, as well as a very light sandy soil. The soil must be deep, and the subsoil free from pan.

Dampness being very hurtful to plant life, the *nursery must be well drained*, and when covered drains approach a hedge flanged pipes should be laid down, as the small chinks in ordinary piping admit roots, which soon choke up the drain, and render it useless.

The land, too, must be thoroughly trenched to a depth varying from eighteen to twenty-four inches, all the surface soil and herbage being placed in the bottom of the trench, and all the larger stones being removed as the work proceeds. After this has been done, *hedges must be planted*, so as to protect the nursery on all sides from the prevailing winds, and at the same time to separate the enclosure into minor divisions or breaks. Beech is most commonly employed for such purposes, and is specially useful for giving shelter, seeing that its leaves are persistent till the following spring. The hawthorn and holly, together or separately, also make a good hedge, and where ornament combined with utility is desired, the English yew will be found of great value. *A cartway* through the middle of the ground, as well as *convenient walks*, must be made for the conveyance of plants, manure, and the like. Trenching is usually performed during autumn or winter, and hedges are planted and walks made during the same period.

Seed-beds may be formed on the newly-trenched land in the succeeding spring; but it is advisable to make these follow a crop of transplanted trees, while the latter do better after a green crop, such as potatoes or turnips, for which the ground should be well manured. Hence, in the case of land newly taken in, seed-beds need not be made until the third season. It need hardly be added that in a nursery every yard of soil should be utilised, and that judicious compression of stock is advisable.

The spade holds its own as yet in the nursery, and may be expected to continue to do so. *In digging*, the thinner the slice and the deeper the spit the better, provided a poor subsoil is not thrown up. The advantage of spade-work is self-evident, for the more open the soil is rendered the greater is the facility afforded to the roots for laying hold of the outside of particles placed in their immediate vicinity. In digging during autumn or early winter, the spit is turned over, so as to remain as entire as possible, thus exposing a greater surface to the influence of the frost; and *in trenching*, the spit placed on the surface is similarly treated. In spring digging, on the other hand, the spit must be turned over, so that the soil may be well comminuted.

After trenching and taking a fallow crop, and previous to the insertion of seedling forest trees, the *hand fork*, if the soil be in a fine friable condition, may be quite sufficient to turn it over, and extract the weeds. In a nursery the latter require to be carefully attended to, and during digging, trenching, or forking operations excellent opportunities occur for destroying them.

In transplanting, it is necessary thoroughly to loosen the soil in the bed with a fork before taking up the seedlings, which, on being lifted, must be kept under cover, in case of injury from exposure. The plants, however, should be reinserted in rows as soon as possible, the distance between the rows and the space between each plant depending on the variety, age, and size of the seedlings. The ground into which these are to be placed is prepared as follows:—A spit of soil is removed all along the break, beginning at the end where the plants are to be first inserted. Digging is then effected over a width of eighteen inches, and after levelling, a line is stretched along the surface, a notch into which the seedlings are to be placed to a slightly greater depth than that at which they stood in the seed-bed being formed alongside of it. After insertion in this notch, the roots must be carefully covered up, and the soil levelled. "*Sheughing*" is often necessary when large quantities of seedlings or transplanted trees are lifted at once, in order to preserve their vitality, until they can be attended to. In this work many plants are placed close together in a groove made in the ground, their roots being covered with soil, which is made firm by the foot.

Spent portions of the nursery soil may be advantageously replenished by applying weeds which have been collected into heaps, covered with earth or turf, and allowed to remain for several seasons, so as to bring about their decay, and the formation of a rich vegetable mould. Mr. Grigor recommends[1] the addition of "one bushel of lime-shell, hot from the kiln, to every four or five bushels of rotted weeds," in order to destroy the fertility of any seeds that occur in the mould.

Farmyard manure is usually applied to the fallow crop, but if directly applied to the tree crop, especially to conifers, or to seed-beds, it must be well rotted. This manure is the best for nursery purposes, and the heaps in which it is stored must be turned over twice during the winter. In putting down the seed, a slight dressing of guano has a stimulating effect, and in July a top-dressing of salt, soot, or guano to seedlings which are looking sickly is markedly beneficial, should rain come to carry the fertilising matter into the soil. *Thoroughly decomposed leaf-mould* may also be applied advantageously to seed-beds.

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[1] Grigor's *Arboriculture*, pp. 38, 39 (1881).

NURSERY OPERATIONS.

These depend entirely on the nature of the season, so that no hard and fast rules can be laid down as to the time of sowing and performing the various operations. The seasonal work, however, may be sketched thus:—

(*a.*) *Spring.*—In February complete winter work, such as digging, forking, and the like. Finish the transplanting of larch and hawthorn, as these come early into leaf, and press on the transplanting of Scots pine, seedlings, and hardwoods. Plant out stocks for future budding and grafting. Plant out stoolery ground, and set the shoots arising from the old stooleries. In March prepare clay for grafting; and during March and April graft beech, oak, ash, laburnum, elm, etc., and finish all transplanting. Ornamental coniferæ, hollies, and hardwoods are pruned in spring.

Collect tree seeds of all kinds.

Sow, in February, yew and holly; in March, alder, beech, and birch; and in April, ornamental conifers in pans, boxes, or in enclosed ground. After April 20, sow larch, silver fir, spruce fir, and Scots pine.

(*b.*) *Summer.*—Throughout summer keep down weeds, especially in seed-beds.

Collect elm seeds as they ripen.

Sow, in May, Scots pine and other conifers, and, in June, elm.

(*c.*) *Autumn.*—Continue to keep weeds down in seed-beds and throughout the nursery. Transplant hollies, laurels, bays, Portugal laurels, and ornamental conifers. Insert cuttings of the laurel bay and Japan laurel. Cut hedges; remove Scots pine attacked by beetle. Larch of one year may be transplanted early in October, if the terminal bud is developed. Towards the middle of October turn over the alleys between the seed-beds.

Collect and pit the seeds of ash, hawthorn, yew, and hornbeam.

(*d.*) *Winter.*—Transplant larch and hawthorn. Transfer as much of the stock to the forest as possible. Dig and trench all open ground. Insert cuttings of willow, privet, poplar, elder, dogwood, and spiræa. Cut down stoolery plants newly put down to five inches above ground. Clean ditches, and convey cleanings to compost heap. Turn manure-heaps.

Collect larch and Scots pine cones, and extract the seed.

Collect and pit sloe and holly berries.

Sow, in November or December, horse-chestnut, hazel, oak, and sloe; and in January ash and hornbeam.

Budding.—Before inserting a bud, it is necessary to see that it has, in addition to its strip of bark, a portion of the cambium (the formative tissue between the bark and the wood) attached. Unless this be present, to unite with the cambium of the stock, the operation will fail. It is convenient in stripping off buds to turn the detached twig upside down. When the bud is prepared, the bark of the stock is cut in a T-shaped manner, and opened with the end of the knife. The bud is then slipped in, and the incision is tied up with bast, which may be removed in six weeks, or sooner if necessary.

Grafting.—A shoot of the plant desired to be propagated is in this operation attached to the stock. There are several methods of grafting, such as saddle and tongue or whip grafting. In the latter, the stock is first cut straight across; the scion, with its three buds, is then cut, and the stock made to suit. The stock and scion are then tied together with bast, and clayed up. The clay may be removed in four or five weeks. In this process not only are the cambium cells of the stock and scion brought together, but portions of the young wood as well.

Clay for grafting.—Clay and straw mixed together with water, so as to form a plastic compound, make a very good workable material. In grafting high up, it is better to use grafting wax, which consists of wax that has been mixed with resin, black pitch, and fat.

Inarching, or *grafting by approach.*—In this operation the scion is brought into union with the stock without being detached from its own stem, and the separation is not made until the new connection has been formed.

THE PINE.

The genus *Pinus* belongs to the natural order *Coniferæ*, and many of the species are raised from seed every year, especially *Pinus sylvestris*, the Scots pine, which is our only native species. It flowers in May and June, and is monœcious.

The mode of fertilisation in Coniferæ is intermediate in character between that of ordinary flowering plants and the higher cryptogams. The pollen, which may be seen in clouds if a slight wind prevails, or if the tree be shaken, has only a limited growth, on its attachment to the strobile, and it does not resume its growth till May of the following season, when complete fertilisation is secured. The completely fertilised cones are ready to be gathered in the succeeding November, but only if they have turned from their bright green colour to a brown. The gathering may be continued till March. In this work great care should be taken to obtain the cones of trees of known merit, so as to prevent any risk of degeneration; those of a long tapering form should be rejected. They should be gathered and stored when dry. At convenience during the winter the cones are placed on a timber kiln, constructed to hold from thirty to sixty bushels at a time, and on the floor of this they are spread to a depth varying from six to eight inches. The spent cones, from which the seed has already been extracted, are burned in a furnace below, and the heated air from the fire, after acting on the closed cones above, passes out by a ventilator. The heat must not be excessive; and the fire must be kept on for several hours. After this the cones in the kiln are stirred about with a rake, and many of the seeds fall down through the floor into a circular cavity beneath. These seeds are then removed, the fire is replenished, and the process is repeated at short intervals until all the seed is shed, whereupon the spent cones are removed for fuel purposes, and fresh ones put on the kiln. The seed, after removal from the kiln, is passed frequently through fanners, and during this process it has to be repeatedly damped. When perfectly clean it is of a fine rich black-brown colour, of small size, and gives off a fine balsamic odour. The seed-coat, or testa, is brittle, and within it there is a layer or coat of albumen, surrounding the germ, which may be easily extracted, and examined by the naked eye. The cotyledons are numerous. The price of pine seed varies with the season.

The seeds of the Scots pine—a tree which grows and also germinates best in sandy loam mixed with a little peat—are winged, and may be observed to fall from the matured cones in April or May, and to spring up naturally where they are deposited by the wind. This natural process of reproduction, however, is much extended by artificial propagation. In Scotland home seed is for this purpose preferred to Continental, although in England the latter is sown. About the beginning of May the seed is turned out, and steeped in water for several days. It is then spread out, and turned several times daily, to prevent heating, and after receiving a coating of red lead, to prevent injury from birds, it is ready for sowing. For its reception the ground has previously been trenched, or otherwise prepared, but before sowing it is again carefully turned over in narrow spits, and raked with widely and narrowly toothed rakes, so as to be thoroughly broken up and weeded. A little manure, well rotted, if not previously added, is dug in as the work proceeds. When four or five yards of ground have been gone over in this manner all along the break, the first bed may be sown as follows:—A line is stretched along the prepared soil twenty or more inches away from the boundary hedge, and after being fixed at each end, the first alley is marked out by treading alongside of the line. Adjoining this, a bed, from three feet six inches to four feet in width, is marked off with a rod at each end, and the line is reset. A second alley fifteen inches in width is next formed; then follows the second bed, and so on.

In order to open up the bed, a "cuffing-board" is required. This is simply a board eight inches in width placed on a handle, which is inserted on the centre towards the back. This tool requires to be in the hands of an experienced person, who stands in either of the two first alleys, and proceeds to push off from the surface of the bed a thin coating of soil from two-thirds of its surface, and along its whole length. Crossing to the opposite alley, the remaining undisturbed surface of the bed is also removed in a similar way. The thickness of the layer of soil thus taken off is regulated by the variety of seed to be sown, the nature of the soil itself, the weather, and other conditions. Immediately after the bed is opened up the seed is sown, the amount used varying according to its quality. This can easily be tested, by examining the embryos of a dozen random seeds, or by having previously had a trial sowing. A little guano or other manure is then dusted over the bed, and a hand-roller is run once up and down, whereupon the soil, which was temporarily deposited along the alleys, is replaced by the "cuffing-board." Should rain fall this board will not work, and the operation has to be suspended, while a hot sun and drying winds greatly endanger the newly-sown beds. If, on the other hand, showers accompanied with heat occur within twelve or eighteen days after sowing, the whole surface of the bed assumes a red appearance, caused by the innumerable embryos shoving up their seed-coats into the air. These coats fall off in a short time, and at this stage birds are very injurious; so that it is necessary to watch the crop from dawn to darkening,—a precaution which would be far less successful were it not for the coating of red lead given to the seed before sowing. Moles, too, are often very destructive at this period, as they plough through the newly-wrought ground in search of worms. They do not, however, eat the seeds or germinating plants, but destroy many by throwing up the ground and exposing the seedlings to drought, which at once kills them. These creatures must therefore be carefully trapped down.

A short time after sowing, a skimming is taken from the alleys, all along the break of seed-beds. The soil thus removed is lightly spread over the beds on each side, these getting the contents of the spade alternately.

Soon after germination hand-weeding must be begun; and throughout summer and well into autumn this must be repeated at intervals—a very light raking, previous to weeding in the early stages, being beneficial. During the following winter a portion of the seedlings are lifted as one-year-old plants, and are planted out in rows seven inches apart, alleys fourteen inches in width being left after every seventh row. This extra distance is important for weeding purposes. After standing for one year in the rows, the seedlings may be planted out in the forest. If, however, they are to stand for another year, every second row must be removed, so as to afford sufficient space for growth during that period. In the winter succeeding their first, the plants left in the beds are called two-year seedlings, and must all be lifted, and planted out in rows varying from ten to twelve inches apart. These seedlings, after standing one year in the rows, are in the best possible condition for the forest, but they may be allowed to stand two years, every second row being removed. The transplanted breaks must be kept free from weeds by frequent hoeings, and at times by hand-weeding.

When in the rows the Scots pine is liable to be attacked by a beetle (*Hylurgus piniperda*). Its presence is indicated by a browning of the leader, or of the side shoots; and on examination the borings of the insect are found to extend upwards through the centre of the shoot or shoots. The seedling is rendered quite useless, and must be at once removed, and burned as soon as possible. In case of a surplus of one-year seedlings, they can be bedded, *i.e.* placed in very close rows for a year.

Our other forest pines are *Pinus austriaca*, or *Pinus nigricans*, the Austrian or black pine, which is raised to a considerable extent, the seed being mainly obtained from the Continent. *Pinus laricio*, the Corsican pine or laricio, and *Pinus pinaster*, the pinaster or cluster-pine, are both successfully planted on the drifting sands of France; *Pinus maritima*, the Taurian or seaside pine; *Pinus strobus monticola*, the mountain pine or short-leaved Weymouth pine; *Pinus pumilo* or *Pinus mughus*, the dwarf or mugho pine, are all raised to a greater or less extent in our forest-tree nurseries, and receive treatment similar to that given to the native pine. In Scotland the native pine is planted more than any of the other species, and deservedly so.

Ornamental Pines.—These, with their varieties, are very numerous, and can be raised from seed in wooden boxes in the open, if protection is afforded during the following winter.

They should be sown in April. The seedlings of the finer varieties are often potted when one year old, and planted out during the next season in rows a few inches apart. Some of the rarest varieties are grafted on Scots pines, which have been established in small pots for some time.

THE LARCH.

Abies larix, or *Larix Europœa*, belongs to the sub-order *Abietineœ*, of the natural order *Coniferœ.* The larch is placed in the genus *Abies*, as a sub-genus *Larix*, by some authors, whilst others regard it as a distinct genus *Larix.*

This magnificent tree was introduced into Britain from the Continent early in the seventeenth century, and is now more extensively planted in Scotland than any other. It is raised by the million every year throughout the kingdom. The larch flowers in April or May, and is monœcious, but fertilisation is not so delayed as in the case of the Scots pine, since the cone is ripe in the following winter. The cone or strobile consists of a mass of imbricated scales with seeds in their axils. In November they may be collected, provided they are ripe, and the work may be continued till March. In collecting, it is very desirable to secure cones from fully matured and healthy trees, although this is apt to be neglected. Cones from diseased trees should be at once rejected.

The cones, when fully ripe, are over an inch in length, and care must be taken not to store them damp. At any convenient time during winter they may be put on the kiln, and subjected to the treatment described for the Scots pine cones. Unfortunately, however, the bracts of larch cones refuse to rise, so that the seed is retained in the cones, hence flailing has to be resorted to. In this way the cones are broken up, and the seed has to be sifted from the débris by means of riddles and fanners. A cheaper and more expeditious process is to place a quantity of cones, which have been on the kiln sufficiently long to render their bracts somewhat brittle, in a grinding-machine, driven by two men. After passing through the machine several (say five or six) times, the bulk of the seed will be extracted. When thus obtained it is mixed with broken bracts and dust, and although a portion may be destroyed, it will, for the most part, be found uninjured. It is thereafter damped and cleaned as far as possible with the fanners—all the dust, light seeds, and lighter portions of bracts being got rid of in this way, but the heavier portions of the last named remain. Home seed is more impure than Continental, as the latter is more easily extracted owing to the better development of the cones, and it germinates better than the former. If equally cleaned, and otherwise placed under similar conditions, however, the two, weight for weight, differ very immaterially as to yield.

The germinating powers of home and foreign larch seed would seem to be regulated by the kind of season which has occurred during the development of the cones. Thus in a given season the home-saved seed may do better than the foreign, or *vice versa*. Foreign plants are more subject to injury from frost in the nursery than those derived from home seed, but seeing that the home supply is insufficient, and that the oldest specimens of larch in the country have been derived from foreign seed, the sowing of the latter continues. The home and continental larch seeds are quoted at prices varying from £7, 10s. to £10 per cwt.

Larch seed is rounder, flatter, and smaller than that of the Scots pine; it has also a harder seed-coat of a brown colour. After April 20, a portion of the larch seed to be sown may be steeped in water, and in a couple of days laid out in heaps a few inches deep. These must be carefully turned several times daily to prevent heating. The seed is then painted with red lead, and sown in the same manner as Scots pine seed. Once in the ground, the crop is liable to injury from drought, birds, and other causes. If the conditions be favourable, however, the plants make their appearance in a fortnight, and soon after must be carefully raked and hand-weeded. The beds must be kept perfectly free from weeds during the summer and autumn. A mixture of soot, salt, and guano has a stimulating effect on flagging plants, if the application be made before a shower.

In the following October, as soon as the terminal buds are developed, all the stronger plants may be removed, and lined out in rows, seven inches apart, giving from six to nine plants to a foot, and making an alley of fourteen inches after every seventh row. During the following year these plants may be planted out in the forest, or may stand another year in the rows, provided every second row be removed. The one-year seedlings do not cast their leaves, but afterwards the larch is deciduous. The beds, which may or may not have been thinned out during the first year, must be cleared when the seedlings are two years of age. The latter in early winter are lined out in rows, say ten inches apart, giving six plants to a foot, and are planted out during the following or the next succeeding year. If they must stand a third year, every second line should be removed. It is often necessary to protect larch seedlings from late or early frosts.

The larch grows best from the seed in a sandy loam mixed with a little peat.

The varieties of the larch are few in number, and can be raised from seed, or grafted on the common *Larix Europæa.*

THE SILVER FIR.

The genus *Picea* belongs to the sub-order *Abietineæ* of Coniferæ. *Picea pectinata* (*Abies pectinata* of some authors) has its foliage persistent, and is not a native. The cones are erect and the bracts deciduous. Cones should be collected in winter. The seed is easily extracted. As home seed is very often not properly developed, continental is preferable. The seed should be sown in the end of April in prepared ground, and receive similar treatment to that of the Scots pine and larch, the amount sown depending on the quality. It contains an ample supply of nutriment for the young plant, and on pressure a resinous juice exudes. The seedlings come up in a fortnight after sowing, and are left for two, or sometimes three, years in the seed-bed, after which they are planted out in rows twelve inches apart. After standing two years in the rows they are ready for the forest.

The silver fir, when germinating, and before it has developed its winter's buds, as well as during the bursting of the buds in spring, is liable to serious injury from frosts. It is advisable therefore to protect the seed-beds or transplanted trees with spruce branches, and further, to avoid sowing or transplanting in soil where there is a tendency to dampness, which would render the plants more susceptible to injury. In the forest the silver fir throws off its early delicacy.

The exquisitely beautiful varieties of this species, such as *Picea nobilis* and *Picea Nordmanniana*, can be raised in the open bed. The cones are gathered when ripe, and the seed is sown at the same time as the common silver fir, the treatment being similar. *Picea grandis, Picea pinsapo*, and others, are sown in the open, and either protected or potted during the winter. *Picea balsamea*, the American or Balm of Gilead fir, is very tender on attaining its first season's growth, and it is preferable to pot the young plants.

These varieties, when a few inches high, are planted out in rows nine inches apart, in which they may stand for several years.

Grafting is resorted to in propagating the rarer species, the stocks for working on having been potted for six or nine months.

THE NORWAY SPRUCE.

The genus *Abies*, like the genus *Picea*, belongs to the sub-order *Abietineæ* of Coniferæ. *Abies excelsa*, the Norway spruce, has persistent foliage. It is not a native. The cones, which are pendulous, are ripe in winter. The fertilisation in the spruce is perfected in six weeks. The seed can easily be extracted from home-grown cones, but is often imperfectly developed; continental seed is therefore usually sown. It is small, resembling that of the Scots pine, and is sown early in May in the bed, in which the plants are left for three years. They are then lifted during the winter of the third year, and planted out in rows ten or twelve inches apart. They are ready for the forest in one or two years.

The *White* and *Black spruces* of North America are raised, with similar treatment, to a limited extent. The other varieties and species of the spruce are numerous and most beautiful. *Abies Douglasii*, the Douglas spruce, from California, is raised to a considerable extent from home-saved seed. The seed is sown in the end of April in the bed in the open; and when the plants are two years old they are planted out in rows ten inches apart, but as one-year seedlings they may be placed more closely. *Abies Canadensis,* and *A. Menziesii,* require greater care in their early stages.

The rarer species and varieties are grafted on stocks that have been established in pots.

THE CEDAR AND THE ARAUCARIA.

These belong to the sub-order *Abietineæ* of Coniferæ. *Cedrus Libani, Cedrus Atlantica,* and *Cedrus deodara,* can all be sown in the open, in the month of April, but, in these circumstances, they must be lifted during the following autumn, and potted in light sandy loam. They must be protected during the winter. The seedlings can be planted out in rows a few inches apart during the following season, or left in the pots for another year.

Araucaria imbricata, the Araucaria or Chilian pine, is raised to a very considerable extent from the seed, which is imported direct from Chili. The plants are diœcious, and the strobili are very large, containing from 200 to 300 seeds, which are edible, and are used as an article of diet by the natives of Chili. The seed, which is fully an inch in length, must be sown in a very finely prepared soil, and grown under glass. The plantlets require a great deal of attention ere they can be lined out in nursery rows.

In sowing the seed should be placed on end, with that end in the soil from which the root proceeds. On attaining a growth of six or seven inches the plantlet has not yet quite absorbed all the nourishment contained in the seed, even although the stem is already provided with its green persistent leaves which are concerned in the manufacture of plant food, and although the root is already furnished with rootlets that are capable of taking in food materials.

THE CYPRESS.

The sub-order *Cupressineæ* of Coniferæ includes the following genera: *Biota, Cupressus* (the cypress), *Libocedrus* (from Chili), *Retinospera* (from Japan), *Thuja* (*Arbor vitæ*), *Thuiopsis,* and others. The species of these genera, which are more or less numerous, are raised from the seed, which is sown in boxes or within enclosures in the open, so that they can be protected during the first winter. If sown in the open, they must be potted in the autumn. They are sown in March, or early in April, in places where they can be protected in case of late frost. If it is intended to sow them in the open, it is better to delay the work for some time. The plants are run out in rows at convenience. In December cuttings of many of the species can be inserted in a light sandy soil with some protection. These can be lined out during the second autumn. Cypress seed can be gathered in autumn. The varieties of the various genera are grafted on stocks established in pots.

THE WELLINGTONIA AND THE TAXODIUM.

Wellingtonia gigantea (*Sequoia gigantea* of some), the Mammoth tree of California, belongs to the section *Taxodiæ* of Coniferæ. The seed, which is imported, is sown in the open bed in April in the ordinary way. The seedlings, having been potted for the winter, are planted out in rows a few inches apart during the following autumn. The Wellingtonia can be propagated by cuttings. The *Taxodium distichum*, or the deciduous cypress, is raised similarly from seed or cuttings. The *Sequoia sempervirens*, or the Redwood of California, is raised from seed.

THE JUNIPER.

The genus *Juniperus* belongs to the section *Junipereæ* of Coniferæ. The native species, *Juniperus communis*, is raised in the seed-bed, but does not come up during the first year. Other varieties, such as the *Juniperus virginiana*, are raised in the open ground. The seedlings are planted out in rows when one or two years old. Choice varieties are grafted on *J. virginiana* which has been established in pots.

THE YEW.

The genus *Taxus* belongs to the sub-order *Taxineæ* of Coniferæ. *Taxus baccata*, the English yew, flowers in March; and the flowers are usually diœcious. Complete fertilisation takes place in six weeks. The fruit, when ripe, is collected and pitted. In pitting, a shallow excavation is made, in which the fruit, well mixed with sand, is deposited. Here it is allowed to remain for fifteen months, after which the seed can be sown. The heap is turned repeatedly during the interval. Sowing is done in beds, and on germination the plants are protected from frost and birds. When two years of age the seedlings are transplanted.

Taxus baccata, variety *fastigiata*, is propagated in the same way, or can be raised from cuttings. The variegated and other ornamental varieties are grafted on the common yew.

THE ALDER.

The genus *Alnus* belongs to the natural order *Betulaceæ.* The flowers are monœcious, and the catkins appear before the leaves. *Alnus glutinosa*, the common or black alder, is the only native species. The fertile catkins are gathered in autumn or winter, and on being kept for some time the seeds fall out. The seed is very light, hence in sowing it requires a very thin covering. It is sown in March. The seedlings may be transplanted when one year old, and on standing a year can be planted out in the forest. From the quick growth of the alder in its young state, it soon becomes unsuitable for nursery treatment. *Alnus incana,* the hoary-leaved alder, requires similar treatment. The ornamental varieties are not numerous; some are very beautiful, and are propagated by layers.

THE BIRCH.

The genus *Betula* belongs to the natural order *Betulaceæ.* The flowers are monœcious, and the flowering takes place in April and May. *Betula alba* and *B. nana* are the only two native species. The fertilised catkins, from which the very light small seeds are easily obtained, are gathered late in autumn. The seed may be sown when gathered, or kept in a dry place till March. It is so small that often in sowing it gets no covering at all, the beds being lightly trodden to press the seed into the soil. If it be sown when gathered, however, a light covering is given. The bed is with difficulty kept free from weeds, as the germinating plants are apt to be picked up with them. *Betula alba pendula*, the weeping birch, is recognisable in the seed-bed by the roughness of its bark. When one year old the seedlings are transplanted, and are ready for the forest in the following season. The plants may be left in the beds till the second year, when they are transplanted, and are ready for the forest in the next season. The other species are raised from seed, and the varieties are inarched on the common species, which must be down one year previous to being operated upon.

THE ASH.

The genus *Fraxinus* belongs to the natural order *Oleaceæ*, whose flowers may be polygamous or diœcious. The flowering takes place in spring, and the fruit is winged, and called a *samara*. *Fraxinus excelsior*, the common ash, is the only native species. The seed can be gathered in October, or later on, and is mixed with sand, and placed in a shallow pit till the following March. The heap is turned frequently. It is sometimes the practice to leave the seed in the pit for fifteen months, and then to sow. The plants are transferred to nursery rows when one- or two-year seedlings, and they are transplanted to the forest in the following year. The ornamental varieties are numerous, and are grafted on the common ash in spring. The growth of the scion is very rapid, and it is advisable to stake it up very soon in case of damage by wind. In grafting the weeping varieties, fine stocks from eight to twelve feet in height are selected, and four or five scions are attached at a time.

THE PRIVET.

The genus *Ligustrum* belongs to the natural order *Oleaceæ*. This plant flowers in June and July. *Ligustrum vulgare*, the common privet, is the only native species. The privet is universally propagated by cuttings, which are made a foot long, and are inserted in the ground in February, or earlier, very close together, in rows one foot apart. They make quick growth, and can be transplanted when two years old. Privet cuttings inserted along the margins of a walk make a good edging, which must be cut back every autumn. The evergreen privet, also the box and oval-leaved privet, are readily raised by cuttings. The Japan privet is grafted on the common variety.

THE PYRUS GROUP.

The genus *Pyrus* belongs to the tribe *Pomeæ,* of the natural order *Rosaceæ,* and includes *Pyrus communis,* the pear-tree; *Pyrus malus,* the common or wild apple-tree; *Pyrus aucuparia,* the mountain ash or rowan-tree; and *Pyrus aria,* the white beam or service-tree. The apple and pear pips can be sown directly when taken from the fruit, or later on. They are grown for grafting purposes. The mountain ash flowers from May to June. The fruit is a berry, which is ripe in autumn, and of which birds are very fond. The seed is gathered and placed in a shallow pit, being well mixed with sand, and turned frequently. During the second spring it is sown in beds in the ordinary way. The plants, when two-year seedlings, are lifted, and placed in nursery rows; after standing a year here they are ready for the forest. The ornamental varieties are very numerous, and are propagated by budding in July, the pinnately leaved kinds on the rowan, and the broad leaved on the white beam stock.

The white beam or service-tree is a native, like the mountain ash, and flowers at the same time. The fruit is like a small pear, and is palatable, birds being very fond of it. The leaves are green on the upper, and white on the lower surface. The fruit is pitted when gathered, and the seed is not sown till the second spring. The seedlings, when two years old, are transferred to nursery rows, and a year later are ready for the forest. In propagating the varieties by budding, the oval-leaved varieties should be placed on the service-tree.

Pyrus torminalis, the wild service, is a native, but very rare.

THE HAWTHORN.

The genus *Cratægus* is placed in the tribe *Pomeæ* of Rosaceæ. *C. oxycantha,* the common hawthorn, is the only native species. The fruit is ripe in winter, and is placed in a shallow pit, well mixed with sand, and left to rot till the pulp is destroyed. The heap is turned over frequently. The seed is sown, twelve or fourteen months after being gathered, in ordinary seed-beds. After the plants have grown one or two seasons in the bed, they are lifted and planted out in nursery rows, and a year later are ready for hedging purposes. The varieties, many of which are very beautiful, are budded on the common stock in July or August. The thorn can be grafted on the mountain ash, very rapid growth of the scion taking place during the first two or three seasons.

THE SWEETBRIAR.

The genus *Rosa* is placed in the tribe *Roseæ* of Rosaceæ. *R. rubiginosa*, the sweetbriar, ripens its fruit—commonly called hips—in autumn. The hips are gathered and pitted. The seed is sown during the second winter after being gathered. The seedlings, when two years old, are placed in nursery rows, and after standing a year they are ready for hedging purposes. The cultivated roses are budded extensively on the briar or dog-rose, *Rosa canina.*

THE COTONEASTER AND SPIRÆA.

The genus *Cotoneaster* is placed on the tribe *Pomeæ* of Rosaceæ. The Cotoneasters are raised from the seed, the fruit having first been pitted. The seedlings, when two years old, are transplanted into nursery rows. *Cotoneaster vulgaris* is a native.

The genus *Spiræa* is placed in the tribe *Spireæ* of Rosaceæ. The Spiræas are numerous, and are easily propagated by cuttings. The cuttings are made ten inches in length, and are, in the month of February, inserted in nursery rows, a foot apart, leaving one inch of the cutting above ground. After standing two seasons they are ready to leave the nursery.

THE CHERRY, THE SLOE, THE COMMON AND PORTUGAL LAURELS.

These are now placed in the tribe *Pruneæ* of Rosaceæ; but Loudon, under the section *Amygdaleæ*, keeps the two genera *Prunus* and *Cerasus* distinct. *Cerasus vulgaris*, the common cherry-tree, *Cerasus padus*, the bird cherry-tree, and the other numerous species, are raised in the nursery in seed-beds. The "stones" can be sown in autumn, or during the winter. Sometimes the plants do not germinate during the first season. The seedlings of two years are transplanted into nursery rows, and after standing a year are ready for the forest, or to be planted out as stocks for budding or grafting. The variety *flore pleno*, the double-flowering cherry, is a highly ornamental tree, and is budded or grafted on the common stock. *Prunus spinosa*, the sloe or blackthorn, may be sown in beds, after the fruit has been well decayed in a pit, or may be sown when gathered. *Prunus sinensis* and *Prunus triloba* are highly ornamental, and are budded on the common plum. *Cerasus laurocerasus*, the common laurel, is commonly propagated by cuttings, which are inserted in sandy soil in the open. After two years the rooted cuttings are transplanted, and the following year are ready to be removed to their final destination. Autumn is the time to transplant, and also to insert cuttings. *Cerasus lusitanica*, the Portugal laurel, is raised from seed, either home or continental, which may be sown in open ground in April, or where protection can be afforded during the first winter. If sown in the open, it must be lifted during autumn and potted for the winter. It can then be planted out next autumn in rows a few inches apart. The plants should be frequently transplanted till they are of a useful size. They are, during their nursery, as in their after life, very subject to injury from frost.

THE BEECH.

The genus *Fagus* belongs to the sub-order *Quercineæ* of the natural order *Cupuliferæ*. *Fagus sylvatica*, the common beech, is a native, and flowers in April and May, the flowers being monœcious. The seed can be gathered in October or November, and sown at once or kept till the following March. The beech is sown in beds or in drills, and after being two years in the beds is usually transplanted into nursery rows. After standing two years in the rows the plants are ready for hedging, but are often re-transplanted, and after a season or two are ready for the forest, or for hedging. *Fagus sylvatica purpurea* may be picked from the seed-beds, or propagated by grafting (taking two years' wood with small buds), or by inarching.

THE OAK.

The genus *Quercus* belongs to the sub-order *Quercineæ* of the natural order *Cupuliferæ*. *Quercus robur*, the English oak, is the only native species, there being two varieties, *sessiliflora* and *pedunculata*. The oak flowers in April and May, and is monœcious. The acorns are single in each cup when ripe, but on cutting a section of a young ovule-bearing female flower three loculi may be seen, so that two are abortive in the adult. The acorns are gathered in November, and sown at once, or kept in a dry place till March. Only the fully matured acorns need be sown. They may be sown in beds or in drills, and transplanted into rows when they have attained their first or second year's growth.[1] The plants are ready for the forest in one or two years more. *Quercus cerris*, the Turkey oak, has leaves with acute lobes, and receives similar nursery treatment. Many beautiful species can be raised from seed, and the varieties are propagated by grafting or by layering.

THE HAZEL.

Genus *Corylus*, order *Cupuliferæ*, sub-order *Coryleæ*. *Corylus avellana*, the hazel, is the only native species. The tree flowers in February and March, the flowers being monœcious. The nuts are ripe in October, and can be gathered and sown at once, or during the winter. The home seed is often not well developed, so that continental is preferable. It should be sown in beds or drills, and transplanted when the plants are one or two years of age. After standing a year or two in the rows the plants are ready for the forest. The varieties are propagated by layers or by grafting.

THE HORNBEAM.

Genus *Carpinus*, order *Cupuliferæ*, sub-order *Coryleæ*. *Carpinus betulus* is the only native species. The tree flowers in May, and is monœcious. It is better to pit the fruit, and sow during the second winter. The plants are transplanted from the seed-bed on attaining their second year, and are ready, after standing a year in the rows, to be removed from the nursery.

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[1] Plants that are to remain for two years in the seed-bed should be loosened with a fork when one year old, in order to check the growth of the tap-roots.

THE SPANISH CHESTNUT.

Genus *Castanea*, order *Cupuliferæ.* The seeds of *Castanea vulgaris,* or the true chestnut, if ripe, and if properly matured, are sown in drills or beds in November, and are transferred to rows when one year old. The ornamental varieties are propagated by grafting.

THE SEA BUCKTHORN.

Genus *Hippophae*, order *Elæagneæ. Hippophae rhamnoides* is the only native species. The flowers are diœcious. It is propagated by cuttings during the winter, or raised from the seed in the usual way.

THE HORSE-CHESTNUT.

The genus *Æsculus* belongs to the natural order *Sapindaceæ. Æsculus hippocastanum,* the horse-chestnut, is not a native. It has usually seven parts in the leaf, and the flowers are polygamous and irregular. The flowering takes place in May. The nuts may be gathered in November, and sown then, or later on, in drills as wide as a spade, alleys fifteen inches in width being left between them. Transplantation is effected with one-year seedlings, as tap-roots are apt to form. The ornamental varieties are budded on the common stock in July.

Pavia Californica, the Pavia, or buckeye horse-chestnut, has only five parts in the leaves, and has no resin on the buds. The cultivation is similar to that of the horse-chestnut.

THE MAPLE.

The genus *Acer* belongs to the natural order *Sapindaceæ,* sub-order *Acerineæ. Acer campestris,* the common, or small-leaved maple, is a native, and flowers from May to June. *Acer pseudo-platanus,* the great maple or sycamore, plane-tree of Scotland, is the only other native. It flowers at the same time. The seeds are ripe in October, and may be sown at once, or kept in sand till March. They are sown in drills or beds, and planted out in rows when seedlings of one or two years. The plants are ready for the forest on remaining in the rows for one or two years. *Acer platanoides*, the Norway maple, resembling the sycamore, is largely raised from seed. The treatment is similar to that stated above. *Negundo fraxinifolium*, the box-elder, is a native of North America, and is raised from the seed, and transplanted when two years old. The ornamental varieties are numerous, and some are exquisitely beautiful. They are propagated by budding and layering.

THE ELDER.

Genus *Sambucus*, order *Caprifoliaceæ*, sub-order *Sambuciæ*. *Sambucus ebulus*, the dwarf elder, and the *Sambucus nigra*, the bourtree, are both natives. The elder flowers in July and August, and the berries, which are ripe in autumn, may be gathered and sown in beds. It is usually propagated by cuttings. These are made about nine inches long, and are inserted in the ground in rows one foot apart, six or eight cuttings being set to a foot. Two inches of the cuttings are left above ground. The plants are fit for removal at the end of the first year. The common elder (*S. nigra*), the scarlet elder (*S. racemosa*), and the white-fruited elder (*S. nigra leucarpa*), are all extensively cultivated.

THE ELM.

Genus *Ulmus*, order *Ulmaceæ*. *Ulmus montana*, the Scots, wych, or mountain elm, and *Ulmus campestris*, are both natives. The elm flowers in March and April. The seed is sown when ripe, in the month of June. The samara is winged all round, and is very light. The seed must be covered lightly in the bed. The seedlings can be transplanted during the first winter. The ornamental varieties are propagated by grafting.

THE HOLLY.

Genus *Ilex*, order *Ilicineæ* or *Aquifoliaceæ*. *Ilex aquifolium*, the common holly, is the only native species. The holly flowers from May to August, and the fruit is a round fleshy drupe. The seeds are gathered when ripe, and placed in pits, well mixed with sand. They are not sown until the pulp is thoroughly decomposed, which does not take place till the following winter. Holly seed should not be sown in stiff ground, as germination is often unequal and much delayed. The seedlings in autumn of the second year are lifted, and planted out in rows seven inches apart, and after every seventh row an alley of fourteen inches may be allowed. When the plants have stood thus for two seasons, all, or every second row of seedlings, must be re-transplanted. They are ready for hedging when five years old. The silver and golden queen hollies, and many other beautiful forms, are propagated by cutting under glass. Grafting on established stocks of *Ilex aquifolium* is also resorted to.

THE LABURNUM.

Genus *Cytisus*, order *Leguminosæ*, sub-order *Papilionaceæ*. The laburnum is not a native. The plant flowers in May and June, and the seed-pods are gathered in autumn. The seed is kept till March, when it is sown in beds. The plants, when seedlings of two years, are transplanted; and on standing a year in the rows, are ready for the forest. *Cytisus alpinus*, the Scots laburnum, may be easily recognised in the seed-bed. It, along with *Cytisus quercifolia*, *C. annularis*, and others, are very graceful, and are budded on stocks of the common laburnum, which have been planted out during the previous winter in rows three feet (or less) in width, with ten inches between each plant.

THE THORN ACACIA.

The genus *Robinia* belongs to the sub-order *Papilionaceæ* of the order *Leguminosæ*. *Robinia pseudo-acacia*, the thorn acacia, locust-tree of America (also called the false acacia, and on the Continent and in Britain the acacia), is raised from seed in the ordinary seed-bed. The seed is imported, and is sown towards the end of April. The seedlings can be transplanted during the following winter. The plants are subject to injury from frost, owing to imperfect ripening of the young wood. The varieties are grafted on the common stock.

THE WHIN OR GORSE.

Genus *Ulex*, sub-order *Papilionaceæ*, order *Leguminosæ*. *Ulex Europæus*, which flowers in February, and *U. nana*, which flowers later on, are both natives. The seed, when ripe, is gathered, and sown in beds. The plants are transplanted for a year, and are in the following year ready for hedging purposes. The whin can also be cultivated as a fodder plant. The double flowering whin is raised from cuttings.

THE HONEY LOCUST.

The genus *Gleditschia* belongs to the sub-order *Cæsalpiniæ* of the order *Leguminosæ*. *Gleditschia triacanthus*, the honey locust of North America, is raised from imported seed, which is sown in beds in April. The seedlings can be transplanted during the first winter. The plants are very susceptible of injury from frost.

THE LIME TREE.

The genus *Tilia* belongs to the natural order *Tiliaceæ*. *Tilia Europæa*, the lime or linden, is a doubtful native of Great Britain. It flowers in summer, but does not ripen its seed in this country, hence the process of layering is adopted for the propagation of the tree. In winter, a stoolery is formed, by planting out some limes three or four feet high, at equal distances, in rows about the same distance apart. In the following November the plants are cut across about three inches from the ground, and are allowed to spring from the root. By this means numerous suckers are formed, which are in February bent down into the ground, and half cut through at the bend. In a year they have taken root, and are completely severed, and transferred to the nursery rows. In two seasons more they can be removed to the forest, or re-transplanted in the nursery. The stoolery, once formed, provides annually a supply of plants for many years. It should be dressed every winter, when the rooted plants are removed, and the new suckers set. Some manure should also be added annually. In putting down a stoolery much ground is taken up. It is best therefore to insert cuttings, or to take some other crop out of the vacant ground for the first two or three years. The ornamental varieties are grafted on the *T. europœa* in spring.

THE POPLAR.

The genus *Populus* is now placed in the natural order *Salicineœ.* *P. alba* (the abele), *P. tremula* (the aspen), and *P. nigra* (the black poplar), are all natives. The poplar flowers from March till April, and the flowers are diœcious. It is universally propagated by cuttings, which are made about eight inches long, and inserted into the ground in February, in rows, twelve inches apart. Two inches of the cutting are left above ground. The rooted cuttings can be planted out during the first winter, or allowed to stand for another season, when, if not planted out, they must be transplanted in the nursery, at wider intervals than formerly. The varieties raised by this means are *P. fastigiata,* the Lombardy poplar, with erect branches; *P. balsamifera,* the balsam poplar; *P. monilifera,* the necklace-bearing, or black Italian poplar; *P. alba,* the abele, or white Egyptian poplar; and *P. Canadensis,* the Ontario poplar. The ornamental varieties are propagated by grafting.

THE WILLOW.

The genus *Salix* belongs to the natural order *Salicineœ.* The willow flowers in April, the flowers being diœcious. The willows which are cultivated for their timber are *S. caprea,* the goat willow; *S. Russelliana,* the Duke of Bedford's willow, and *S. alba,* the common willow, which is found by river-sides. These are all propagated by cuttings, and so, too, are *S. viminalis,* the twiggy willow, and the *osiers,* the yearly shoots of which are cut for basket-making, and other purposes. The cuttings may be made nine inches long, and are inserted in rows a foot apart. On standing for one or two years they are ready for the forest. They are often transplanted in the nursery. Loudon gives over eighty species of the willow, of which about twenty are natives.

THE WALNUT AND HICKORY.

The genus *Juglans* belongs to the natural order *Juglandaceæ*. The flowers are monœcious, the male flowers being in catkins, and the female in terminal clusters. The "nuts," which are usually imported, are sown in drills in November, or kept till March. The seedlings are transplanted during the first winter, as tap-roots are apt to be formed. After standing for a year or two in the rows, they are ready to be turned out from the nursery, but are often kept much longer. *Juglans regia* and *J. nigra* are both propagated in this manner.

Carya alba, the hickory, is a tree which produces splendid timber of a very compact grain. It is propagated from "nuts," and is a native of North America. It does not, however, suit our climate well.

THE STRAWBERRY-TREE, RHODODENDRON, GAULTHERIA, AND AZALEA.

These beautiful shrubs are all placed under distinctive genera of the natural order *Ericaceæ*. *Arbutus unedo*, the strawberry-tree, is probably indigenous to Ireland. The fruit is gathered when ripe. Imported seed is often sown in open ground about the end of April; after having been potted in autumn. During the following summer the seedlings are planted out in rows. This species should be planted in peaty soil; if not so placed a mixture of sand and peat should be added as the plants are inserted in the rows.

Rhododendron ponticum, the common rhododendron, or rose bay, ripens its seed in autumn, when it should be gathered. In the month of April it is sown in a frame, which has been filled with a mixture of peat and sand. The light seeds must be covered very thinly. The plants will soon come up if the seed is good. They must be carefully watered and weeded, and the covers of the frames may be removed during the day. The seedlings, after having stood for two seasons in the seed-bed, are lifted and lined out thickly for a year. During the following year the plants may be lined out in the open in rows eight or nine inches apart, in peaty soil if possible. If this cannot be obtained in the nursery, peat and sand should be added when the plants are being run out in rows. The other species are treated similarly. The hybrid varieties are grafted on the *R. ponticum* in February, and after being tended inside till the month of July or so, are planted out in the open.

Gaultheria shallon and *Gaultheria procumbens*, natives of North America, are shrubs which yield berries of which game is said to be very fond. These are raised from seed in the nursery.

The *Azalea* is raised in a manner similar to the rhododendron.

THE AUCUBA.

Genus *Aucuba*, order *Loxanthaceæ.* The flowers are diœcious. *Aucuba Japonica*, the Japan laurel, can be raised from cuttings, which are inserted in a frame filled with sharp sand in August or September, and are protected during the winter. During the succeeding autumn the rooted cuttings are set in rows a few inches apart. The fine varieties are grafted on *A. Japonica* that has become established in pots.

THE BARBERRY AND MAHONIA

belong to distinct genera of the order *Berberidaceæ. Berberis vulgaris*, the common barberry, is a native, and is raised from the seed, which has previously been pitted for fifteen months. The seedlings, after having two seasons' growth in the bed, are transferred to nursery rows, and after standing a year are ready for the forest.

Mahonia aquifolium, the holly-leaved Mahonia, or ash-berry, is not a native. It flowers most luxuriantly in early spring, and the berries require to be well rotted in a pit before the seed which they contain is sown. This is done in beds, and transplantation is carried out two years later.

THE BOX.

The genus *Buxus* belongs to the order *Euphorbiaceæ. Buxus sempervirens*, the common box, and *Buxus Balearica*, the Balearic box, are both propagated from seed. The dwarf variety of *Buxus sempervirens* is propagated by division, and is used as an edging in every garden.

THE DOGWOOD.

The genus *Cornus* belongs to the natural order *Cornaceæ*. The species, two of which are natives, are propagated by cuttings, which are made about nine inches long, and are in the month of February inserted in the ground. After standing one or two years they are ready for the forest.

THE RIBES.

Genus *Ribes*, order *Grossulariaceæ*. The members of this genus are propagated by cuttings made about ten inches long. These are planted out in rows a foot apart in February. There are numerous varieties cultivated in gardens.

THE DAPHNE.

Genus *Daphne*, order *Thymilaceæ*. *Daphne laureola*, the spurge laurel, is a native of England. The seed is sown in April, and the seedlings are potted off in autumn, and may during the following summer be planted out in rows a few inches apart. *Daphne mezereum*, the *mezereon*, a doubtful native, is propagated in the same manner.

THE PHILADELPHUS OR MOCK ORANGE.

Genus *Philadelphus*, order *Philadelphaceæ*. The species are propagated by cuttings, which are made about ten inches long, and are inserted in rows one foot apart, one inch of the cutting being left above ground.

THE SPINDLE-TREE—genus *Euonymus*, order *Celastraceæ*. This tree can be obtained from cuttings in the open. It is a native of the British Isles.

THE IVY—genus *Hedera*, order *Araliaceæ*—is propagated by cuttings, which are made about twelve inches long, and inserted in rows during the winter.

THE ST. JOHN'S WORT—genus *Hypericum*, order *Hyperaceæ*—is propagated by layers.

THE HONEYSUCKLE—genus *Lonicera*, order *Caprifoliaceæ*—is propagated by cuttings.

THE LILAC—genus *Syringa*, order *Oleaceæ*—is not a native. It is propagated by suckers.

THE MULBERRY—genus *Morus*, order *Artocarpaceæ*—is not a native. It succeeds better in England than in Scotland. It can be propagated by layers.

THE BUCKTHORN.—Genus *Rhamnus*, order *Rhamnaceæ*. *R. catharticus* and *R. frangula* are both natives of England, and are propagated from layers.

THE LAUREL OR BAY-TREE

The genus *Laurus* belongs to the natural order *Lauraceæ*. The seeds are sown, after having been previously pitted in sand, in a bed. The seedlings are potted during the following autumn, and planted out in rows a few inches apart a year after. Continental seed is often sown.

THE TULIP-TREE.

The genus *Liriodendron* belongs to the natural order *Magnoliaceæ*. *Liriodendron tulipifera*, the tulip-tree, is not a native. The seed is sown in April in the open, and in autumn the seedlings must be potted. The foliage is deciduous, and the plant is liable to be injured by frost in the nursery.

THE PLANE-TREE.

Genus *Platanus*, order *Platanaceæ*. The two varieties *P. orientalis* and *P. occidentalis* are both raised from the seed, or from layers. The seedlings are very susceptible to injury from frost, and must be protected during the winter. The seed-bed should be in a well-sheltered situation.

THE VIBURNUM.

Genus *Viburnum*, order *Caprifoliaceæ*. *V. opulus*, the Guelder rose, *V. lantanum*, the wayfaring-tree, and *V. tinus*, the *Lauristinus*, are natives. They can be propagated by cuttings. The *Lauristinus* may also be raised from the seed, while the Guelder rose may be grafted on its own roots.

III.

THE FORMATION AND MANAGEMENT OF PLANTATIONS ON DIFFERENT SITES, ALTITUDES, AND EXPOSURES.

By Donald Stalker, *Murthly Castle, Perthshire.*

By the enterprise of landed proprietors, the Highland and Agricultural Society of Scotland, and still more recently by the action of the Arboricultural Society, extensive planting of moorlands, which has largely contributed to beautify and enrich the Highlands of Scotland, has been effected within the past century. Such work is especially beneficial in the case of steep and rocky ground, which is valueless for grazing purposes, and impossible to reclaim or bring under cultivation, inasmuch as by judicious management very barren soils may be acted upon so as to yield sustenance for the growth of trees of fair dimensions, the result being an increase of revenue to the proprietor, of beauty to his estate, and of permanent employment for the peasantry on his domains. Moreover, well-wooded estates on coming into the market readily find purchasers, although the trees may have been planted only for a period of twelve or fifteen years; whereas barren moorland properties are with great difficulty disposed of to advantage.

In the Highlands, it is obvious that the cultivation of the deserted glens, and the planting of barren and rocky hill-sides with serviceable trees, should be energetically prosecuted in the future as tending to open up and develop one of the most desirable and picturesque countries in the world.

The first important consideration to be attended to in marking out hill ground for planting purposes is that no land capable of being reclaimed and brought under cultivation at a reasonable cost should be taken within the enclosure, unless this is absolutely necessary for sheltering or beautifying the adjoining areas. Attention should next be directed towards guarding against the planting of ground on which cattle and sheep stock depend for wintering. A hill-side, for instance, containing thousands of acres, may, from its base up to a certain height, be admirably adapted for the growth of valuable trees, while beyond this there may be excellent summer pasture, which from its exposure may be totally unsuited for wintering stock. In such a case it would be a mistake to plant all the available low-level ground, inasmuch as this would injuriously affect the grazing on that portion of the estate.

Highland estates are invariably improved in appearance by having their extremities planted where practicable, and in the case of such as have inferior pasture covered with heather, it would be far more remunerative for the proprietor to expel the stock from his territory altogether, and to plant the whole with trees adapted to the various soils and situations.

The boundaries of plantations, where they are not regulated by roads, rivers, arable fields, or the limits of an estate, should be laid off in curving lines, so as to form a series of spacious recesses in which the flocks on the adjoining grazings might congregate in inclement weather during the lambing season, and for this purpose it is desirable that the ground along the outside of the fence should be naturally dry.

THE DRAINING OF GROUND FOR PLANTATIONS.

Crops of timber trees may, like many farm crops, be planted on ground surcharged with water, but an action so unwise can only lead to bitter disappointment. All the wet ground planted on the Benmore and Kilmun estates in Argyllshire was thoroughly drained by contract, and also by men employed at a fixed rate of wages per day. The method adopted in drying the steep and rocky enclosures was such that all the wet ground was wrought by "surface drainers," who, with "big spades," and other tools specially adapted for the purpose, performed the work far more expeditiously than could possibly have been the case by using the ordinary spades or shovels, and at less than a fourth of the price. The drains were made from two feet to two feet three inches wide at the top, twelve to eighteen inches deep, and from six to eight inches broad at the bottom in places where the soil admitted of that depth, and the cost of construction varied from 1s. 9d. to 2s. 6d. per 100 yards.

In deep loamy and mossy soils open drains were formed by contract and also by day-labourers. The dimensions were from two and a half to three feet broad at the top, two feet to two feet nine inches deep, and six to nine inches broad at the bottom, according to the soil, which, when taken out, was spread over the surface of the ground. The cost was from 9s. to 12s. per 100 yards.

The position in which such conduits should be placed depends wholly on the nature of the ground, which in many parts may be most effectively dried by opening them across the slope, while in other cases the drains should run straight up and down the incline. The former are best suited for preventing the water on the heights from spreading on the lower areas, but the latter are most serviceable on ground comparatively level, and of a deep loamy or mossy nature. Stone, tile, or any other kind of covered drains, are not suited for places under trees, as they in process of time get choked through the enlargement of the roots.

FENCES.

Stone and turf walls are now entirely superseded by wood and iron fencing, the most common at present being that which goes under the name of the "Corriemony Fence," and of which there are so many designs that on almost every estate where it is erected a different one is to be met with. Be the design what it may, however, the standards should in no case be placed wider apart than twelve yards, and the height of the fence from the ground should never be less than three feet four inches. If, moreover, the adjoining ground be pastured with sheep, it should contain seven wires. The most substantial and ornamental fence for avenues, park-clumps, or road-sides, is that formed by the "continuous wrought-iron bar."

The following may be taken as a specification for a most durable and cheap fence suitable for the boundary of a plantation, viz.:—"Fence to be 3 feet 4 inches high, with seven wires of best bright wire, two No. 6, and five No. 7 W. G. Standards to be 1¼″ × ⅜″ in size, and placed 6 feet apart, and batted with sulphur or lead into stones, each weighing three cwt. Straining-posts to be 1⅜″ square, with stays ⅞″ square, placed 120 yards apart, and batted into stones of sufficient weight with lead. The whole fence to receive two coats of tar after erection, and the ground, where deficient, to be made up to within 5 inches of the lower wire. The contractor to do all carting, etc. Where stones cannot be found, and where the ground is boggy, so that it will not carry stones, wood block bases of fir, each containing not less than 1½ cubic feet of wood, with standard fixed to same by two spikes, and charged at 1s. 3½d. per standard, to be used—the blocks to be sunk into the ground not less than twelve inches." The cost of such a fence varies from 1s. 1d. to 1s. 2½d. per lineal yard where the ground is firm and stones are obtainable. Plantations formed on land overrun with ground game should be enclosed with wire-netting, or the game should be completely extirpated before a single plant is inserted.

PLANTATION ROADS.

These are absolutely necessary for ascertaining the state of the trees, sporting purposes, the removal of timber, and for access to the forests generally. All plantations should be well intersected with roads and walks, which should be either made or lined out before planting operations commence. A practical roadman should be appointed to superintend the work, which ought to be carried on during the summer and autumn months. If properly lined off, £1000 goes a long way in constructing plantation roads and bridle-paths, as they do not require to be metalled, but merely to have the surface equalised, and well drained by "catch-water" and side conduits where the ground is wet. All the gravel taken out in forming the drains ought to be spread on the centre of the road, and if the quantity so obtained be insufficient, a pit should be opened in close proximity, and the natural subsoil or gravel utilised for completing the work. Roads should be formed from twelve to fifteen feet, and bridle-paths from four to five feet, in width, and no trees should be planted closer to their sides than six feet. Passes twelve feet in width may be left unplanted for sportsmen.

AGE AND SIZE OF FOREST PLANTS FOR VARIOUS SOILS AND SITUATIONS.

The most extensive plantation of which I superintended the formation is situated on the estate of Strathkyle, on the western border of Ross-shire. The exposure is north-western; in extent it measures 3950 imperial acres, and rises gradually from 100 to about 1200 feet above the level of the sea. This area was planted with about eight and a half millions of forest seedlings. The surface, which was covered with heather, consisted chiefly of sandy peat, and the subsoil of deep open gravel. Larch plants with a mixture of Scots pines were inserted where the peaty surface-soil was only a few inches deep, and also where dry loamy slopes and burn-sides occurred, while deep mossy parts and exposed ridges were planted with Scots pines only. Norway spruce and black Italian poplars were placed in several localities where the soil was of a deep loamy and mossy nature. The pines used were seedlings of two years of age, and one year transplanted; seedlings of one year, one year transplanted; and seedlings of two years. The strongest plants were always placed where the ground was covered with rank heather. The Norway spruce plants were seedlings of two years, two years transplanted, and the poplars varied from two and a half to three and a half feet in height.

A public road intersected the plantation, and along this road, at intervals varying from twelve to fifteen feet, a belt of several varieties of common deciduous trees, from three to four feet in height, was formed.

Hardwood plants were pitted, but all others were notched into the ground with common garden spades. They were planted at intervals varying from four to four and a half feet. The ground generally possessed a regular surface, and was well intersected by roads used for carting peat fuel. Extensive portions of it were naturally dry, while other parts had to be artificially drained.

The cost of forming this extensive plantation, including fencing, draining, plants, and planting, did not amount to over £2, 10s. per acre.

In its original condition the ground formed a bleak and barren moorland, which the crofters, who used it as a common for their cattle and sheep, absolutely refused to rent at 1s. per acre per annum.

Planting operations were commenced in 1872, and completed in 1877, and at present the trees are, especially on the lower portion, speedily developing, the larch having attained to the height of fifteen feet. On the uplands, however, such a marked degree of growth has not taken place, and towards the summit of the hills, where the soil is cold, mossy, and exposed, they are as yet making but slow progress, and in all probability will continue to do so until such time as their branches begin to meet and shelter each other.

In Argyllshire, the properties of Benmore and Kilmun are contiguously situated in the united parishes of Dunoon and Kilmun, on the Firth of Clyde, in the southern border of the county. The total area of these estates is 12,260 acres. The ground is steep and hilly, yet it affords excellent pasture. On obtaining possession of the estate in 1870, the proprietor at once resolved on effecting extensive improvements. These he carried out by means of draining, ploughing, and bringing under cultivation such portions as were adapted for that purpose, and also by planting serviceable timber trees on barren hill-sides too steep and high for arable land. Before planting operations were commenced, abundant evidence of the adaptation of soil and climate for the successful growth of timber was obtained from a plantation, formed about sixty-five years ago, immediately behind Benmore House, and chiefly designed with the view of contributing to its amenity and shelter. The trees have grown to large dimensions, are of good quality, and perfectly sound.

Since 1871 thirty-three separate enclosures have been planted, the extent of which amounts to about 1642 acres, and the number of trees used amounts to 6,565,000.

Within the enclosures the ground is very steep; some portions are undulating and rocky, while others are comparatively smooth and regular on the surface, which, with the exception of the tops of ridges and other rocky parts, consists of deep sandy loam, yielding a mixed growth of heather, grass, and brackens. The substratum throughout the entire estate is clay-slate alternating with narrow veins of quartz.

The lower boundaries of most of the enclosures range from ten to one hundred and fifty feet above sea-level, but two of the hills have been planted to a height of about 1200 feet, and like most hilly ground, some parts were naturally dry, while others required artificial draining.

Six of the plantations contain respectively 205, 320, 170, 280, 283, and 100 imperial acres or thereby, while in addition, twenty-seven belts and clumps, amounting to about 284 acres, were planted throughout the estate, principally for ornament and shelter.

These shelter belts extend from the base of the hills to an elevation beyond which trees could scarcely be expected to grow, and are from 60 to 400 yards in breadth. Similar narrow belts have also been planted round some arable fields for a similar purpose, and on the one side of each of them hedges of *Thuja gigantea*, *Cupressus Lawsoniana*, and Norway spruce have been formed. When forming the plantations strict attention was directed to the soil, specially with a view to its suitability for the various species of trees about to be planted. In hollows, larch plants with several varieties of coniferous and deciduous trees were inserted. Norway spruce was set in damp grassy parts; and in places where brackens and grass fought for mastery *Picea nobilis*, black Italian poplars, and sycamores were placed; while on bleak rocky ridges or exposed knolls there were planted *Pinus austriaca*, *Pinus laricio*, *Pinus montana*, and *Pinus sylvestris*.

Along the margin of the plantations, and other places in congenial soil at moderate altitudes, ornamental conifers, associated with larch and other trees, have been placed at intervals varying from twelve to thirteen feet. A more commendable method, however, in regard to conifers, has now been adopted, viz. their arrangement in clusters, each species being planted separately. In this way a much more telling effect is produced, and the cutting down of valuable larch-trees in order to give the others room is avoided.

Larch, with an admixture of deciduous trees only, should be inserted into plantations formed for utility wherever they might be expected to thrive, and groups of the different kinds of ornamental conifers, or of any species of evergreen trees, should be formed here and there, so as to give verdure during the winter. Plantations of small extent designed for shelter or ornament are usually more attractive when they contain a variety of trees, evergreen forming the largest proportion.

On the Benmore estate, both public and private roads intersect some of the plantations, and along these, immediately behind the fencing, there are lines of deciduous trees, and of evergreen and flowering shrubs, comprising purple beech, walnut, gean, purple and variegated planes, common hawthorn, single and double flowering hawthorn, common and golden laburnums, lilacs, bay and Portugal laurel, common and variegated hollies, *Rhododendron ponticum*, *Mahonia aquifolia*, cotoneasters, etc.

Two of the plantations have an easterly, a few have a southerly, but all the others a north-westerly exposure. From the base of most of the enclosures to a height of about 800 feet the trees are, with few exceptions, thriving admirably; above this altitude, however, they are not growing well, and it has been resolved not to plant ground at a higher elevation than 800 feet, but to devote every attention to the base of the hills, where the trees are developing with such vigour and uniformity.

The expense per acre, including draining, fencing, plants, and planting, on such ground, overspread with grass and brackens, usually ranges from £4 to £12.

Of the rare and ornamental conifers at present growing on Benmore estate the following are the most deserving of notice:—

Abies Douglasii, planted eleven years ago, are now from fourteen to eighteen feet high. This is an evergreen tree of unsurpassed beauty, and grows as quickly as larch in congenial soils and sheltered situations, but for mixing with other trees on exposed hill-sides it is totally unsuited, being unable to struggle through the first gale of wind which occurs subsequent to the first thinning of the plantation. In low humid soil, where larch unfortunately becomes diseased at a very early age, *Abies Douglasii* forms a very profitable substitute, and as an ornamental tree in sheltered glens by burn-sides it is unequalled.

Picea nobilis is also a magnificent tree, and grows well in such soils and situations as are adapted for larch. It is well suited for planting in ground overspread with brackens or grass, neither of which retards its progress in the least, after the plants are a foot high, while, compared with most young trees, it has the advantage of security against the ravages of hares and rabbits. The tips of the branches of a few plants may be nibbled a little, but it is customary to plant *Picea nobilis* and *Pinus laricio* where those pests abound, as they remain uninjured when all other small plants are devoured.

Thuja gigantea in a few instances, and in alluvial soil, rivals the larch as a rapid grower, and being an evergreen it is amongst the best for planting in belts for shelter.

Picea grandis in free open loamy soil grows here at the rate of three feet per annum. There are, however, only a very few trees on the estate altogether, yet these are very graceful, and perfectly hardy.

Picea Nordmanniana is a very successful grower after being a few years planted, but somewhat sluggish when young. Plants inserted ten years ago, and then three feet in height, are now twelve feet high, and making annual topshoots of from twelve to sixteen inches long. It is a native of the Crimean mountains, and is classed amongst the hardiest of the silver-fir tribe.

Abies Menziesii in good loamy soil is a rapid grower, but many plants, in hard, dry gravelly sites, after attaining to the height of only a few feet, begin to cast their leaves, and thereafter gradually decay.

Pinus laricio and *Pinus austriaca* are very desirable forest trees, and of rapid growth, but being barely rooted they have but little security in loose open soil against violent storms.

There are many other conifers of recent introduction, and of an exceedingly ornamental character, which are making rapid progress throughout the plantation, notably *Wellingtonia gigantea, Cupressus Lawsoniana, Abies Albertiana, Abies nigra, Abies orientalis, Cedrus Atlantica, Cedrus deodara, Araucaria imbricata, Pinus excelsa, Pinus strobus, Picea cephalonica*, and others; but the varieties which at present give any promise of becoming useful timber trees in this country are *Abies Douglasii, Picea nobilis, Thuja gigantea, Picea grandis, Abies Menziesii,* and *Pinus laricio.*

On the careful selection of healthy well-rooted plants of the proper species depends to a very great extent the future success and value of the forest; for unless the young trees are hardy and healthy to begin with, a crop of valuable timber need not be expected. In afforesting moorland covered with heather the following seedlings succeed best, viz.:—

Larch seedlings, one year old, and one year transplanted.

Scots pine seedlings, two years of age, and one year transplanted.

Norway spruce seedlings, two years of age, and two years transplanted.

Silver firs, two years of age, and two years transplanted.

Hardwood seedlings, two years of age, and one year transplanted, are best adapted for the most exposed bleak sites, but for more sheltered situations plants from two and a half to three and a half feet high, having been twice transplanted, are the most serviceable.

For land overspread with a rank surface vegetation of grass, brackens, whins, broom, etc., all the conifers should be at least one or two years older than is necessary when they are inserted among heather.

The following are best adapted for such ground, viz.:—

Larch (three years of age), one year seedlings and twice transplanted.

Scots pines (four years of age), two years' seedlings and twice transplanted.

Norway spruce (five years of age), two years' seedlings and twice transplanted.

Silver fir, and all other kinds of ornamental conifers, should be from twelve to eighteen inches high, and should have been transplanted the year previous to their being placed out in the forest.

Plants of this description are not always to be obtained in public nurseries, consequently either orders must be booked for them a year or two previous to their being required, or intending planters should set aside a suitable portion of a field of good arable land, neither too much exposed nor sheltered, to be used as a nursery, in which case seedlings or one-year transplanted plants might be purchased in public nurseries, and transplanted for one or two years as might be required.

Overcrowding in the nursery should be carefully avoided, and weeds should be kept down, in order to facilitate the development of all their branches. In this way superior well-rooted plants, capable in a great measure of surviving against a heavy sward of close herbage, may be obtained, and although they do cost a few shillings more per thousand in the first instance, in the long-run they are the cheapest, as the often recurring, disheartening, and expensive work of "beating up" the plantations becomes unnecessary.

A private nursery is also a useful and convenient possession for fostering trees and shrubs for avenues, lawns, and parks, as they may be frequently transplanted, pruned, and trained for whatever purpose they may be ultimately designed.

A question demanding careful attention in the formation of plantations is the allocation of the different kinds of trees to the soils and situations most suited for their growth, and in making this selection the forester is commonly well guided by the configuration of the ground, as it generally indicates clearly where the several kinds should be planted. Soils most conducive to the growth of larch, for instance, are frequently found on the margins and sloping banks of watercourses, in the hollows and sides of depressions in undulating moorland, and on mountain sides over which rivulets have for ages been depositing the various kinds of soil carried down from the heights. In such alluvial deposits, too, our common hardwood, and most of the hardy ornamental conifers of recent introduction, will grow luxuriantly.

On bleak moorland, or on the tops of exposed ridges with a surface soil of moss incumbent on dry hard gravel or rock, larch will not prosper, but on such Scots pine, *Pinus austriaca*, and *Pinus montana*, with a mixture of birch, will flourish. Mountain ash, too, and alder will there find a favourable habitation. In rich, deep, fertile and low-lying lands larch will not subsist for many years, as in such soils it is, at an early age, very liable to become diseased; here however poplars, limes, and most hardwood trees, and the several species of spruce, will grow vigorously.

In planting ground pits should be formed for all kinds of trees exceeding eighteen inches in height, or for all that have roots too large and bulky for insertion by the notching system. Hardwood trees should be inserted first, at from twenty to thirty feet apart, throughout all the ground adapted for and intended to be planted with larch. The pits should be of a size sufficient to admit of all the roots being spread at full length, and to allow of three or four inches of loose soil to exist between the extremities of the roots and the sides of the pits.

The pits are marked off by one man and dug out by several. These are succeeded by a man with a pick, who opens up and thoroughly loosens the subsoil; another carries the plants from the "sheugh" to the pits, in which the planters, who follow up closely, deposit them. The surface turf, if covered with heather, is pared off as close to the ground as possible and rejected, but if grassy it is thrown into the bottom of the pit, and after being broken down with the spade is covered with a few inches of fine earth, so as to make the pit of the required depth. The plants are then inserted, and as the finest of the soil is being filled in, they are gently moved into the erect position before the roots are entirely covered. The operation is completed by the addition of more soil, which is carefully packed round the plants, so as to fill up the pits and render the seedlings erect and firm. The young trees are bedded one inch deeper in the soil than they were in the nursery.

Notch-Planting is the most expeditious, cheapest, and altogether the best method for inserting into moorland most forest plants under eighteen inches in height. The implement most serviceable for the purpose is the common garden spade. There are two forms of notch in general use, viz. the L- and the T-notch. The former is resorted to in cases where the soil is free and open, but the latter is decidedly the better for loosening the subsoil where it is compact and firm. Soils too hard for the spade should be either loosened with the foot-pick or shoulder-pick, but under such circumstances pitting is preferable.

Ground covered with heather from six to nine inches high is in the best possible state for the reception of plants, but where rank heather exists it should either be pulled or cut for a space varying from twelve to fifteen inches square where the plant is to be set. Heather thus pulled or cut should be packed well down in order to prevent it from being blown on the top of the seedlings.

Notches, unless well closed up, are very apt to open during protracted dry weather, and the young trees in consequence suffer to such an extent as rapidly to wither and die. It is therefore of the utmost importance that the turf disturbed in forming the slits should be stamped down firmly and closely. A prevalent practice in planting grassy land is to cut out and remove about a square foot of the surface where the young trees are to be inserted. This plan was adopted in forming a few of the Benmore plantations, but has been for the last three years altogether abandoned, as it was found that the plants grew much better, and that there were fewer failures when the grassy surface, which greatly protects and shelters the young trees on exposed situations during winter, was not interfered with further than by cutting any rank grass which might impede the progress of the young trees during the summer.

The distance at which plants should be placed from each other ought to be regulated according to circumstances. If there be no winged or ground game to injure them, nor rank grass, whins, broom, or other strong vegetation to interfere with their upward progress, then from nine to twelve feet apart would be amply sufficient; but assuming that all will not grow that are planted, that many of those which do luxuriate for a time will be by disease and other casualties rendered useless, and also that a certain amount of shelter is absolutely necessary on exposed ground, it is essential, in prospect of having a uniform crop of superior timber, to resort to close planting.

When forming Benmore plantations the young trees were placed at from three to three and a half feet apart, giving an average of 4000 to the acre. The plants were transported to their new places by four Shetland ponies, on whose backs pack-saddles were strapped. Into these saddles the bundles of plants—which were taken from the dry ground, where they had previously been "sheughed" at the base of the enclosures—were placed (roots inward). On reaching their destination the seedlings were again "sheughed" close to the place where the planters were at work. The usual number of men engaged in notching was about a dozen, while two lads were fully employed in supplying young trees to the boys and girls, who inserted them into the notches as they were being formed.

The work should be performed under the constant supervision of the forester and an assistant.

When planting is going on, scrupulous care should be taken that the seedlings are not crowded for an unnecessary length of time in a "sheugh," as this is very detrimental to their welfare; and that, on removal, their roots are not allowed to get dry by too long exposure either to sunshine or withering winds. The proper period for afforesting ground naturally dry extends from the 1st of November to the end of December, but in the case of wet and retentive soil, necessitating close draining, spring is undoubtedly the most suitable time for such work. All kinds of forest trees should be inserted before the buds begin to expand.

THE MANAGEMENT OF PLANTATIONS.

The success and ultimate value of forest crops, in common with every other industry, is entirely dependent on their management. Hill ground under useful timber, judiciously and economically treated, frequently yields a return equal to, and in some cases exceeding, that of arable land. From the earliest stages of development the young trees are at the mercy of wind and weather, and have frequently after violent storms to be put up again. Attention has also to be directed towards the clearing away of such surface vegetation as tall grass, brackens, whins, etc., which would interfere with the progress of the young trees. Grass should be either cut with shearing-hooks or well trodden down with the feet. Brackens ought to be cut down about the beginning of June, and as they appear almost as strongly during the following month, the work must be repeated. If this be done for two consecutive seasons they are unable to do the trees any further injury. Whins are more troublesome, and ought to be destroyed with sharp spades or shearing-hooks every year, or on alternate years, until they are suppressed by the branches of the trees.

It is of the utmost importance that plantation drains be kept clear of all obstructions, for if this be neglected many of the trees remain no longer in a healthy condition.

THINNING.

All plantations require thinning whenever the trees are observed to press too closely on each other; and when such is the case no time should be lost in removing those whose development is most backward.

That one of the causes operating in the propagation of disease in larch is attributable to the neglect of early thinning is extremely probable, inasmuch as gales of wind may suffice to remove the insect (*Coccos laricis*) from thinned portions of a forest, but cannot dislodge it from sheltered unthinned spots. In thinning-work the ultimate good of the timber left ought to be the primary consideration. The outskirts of plantations should be kept thicker than the other parts, so as to intercept the force of violent gales, and thereby prevent havoc in the interior. The distance between trees in a healthy plantation of thirty-five or forty years' growth should vary from ten to fourteen feet,[1] but in shelter belts or clumps they ought to be kept much closer.

PRUNING.

In every plantation a great many young trees, with two or more topshoots or leaders, require to be pruned, and unless all are cut down except the best ones, such trees seldom become valuable. Conifers, such as larch, spruce, and pine, seldom require any more pruning than is necessary for the purpose of keeping the leaders single—the ruinous system of stripping the stems of young Scots and other pines upwards for several feet, by pruning off living branches, being now abandoned. Hardwood, and all other deciduous broad-leaved trees, generally require more or less pruning, in addition to the removal of rival leaders, which is necessary in order to produce straight, clean timber. This end is also partly attained by shortening any strong branches that are likely to cope with the main stem. The time most favourable for performing this work is towards the end of autumn. As hardwood plants often become stunted after being inserted in the forest, all such specimens should be cut over, within one or two inches of the surface of the ground, during the months of November or March, so that strong healthy shoots may spring up during the following summer. The choicest of these should be retained, and all the others cut off close to the stem, during the month of March of the succeeding year.

FELLING.

The first thinnings of plantations are of little value, unless there be a demand for them in the immediate locality for rustic fences or firewood. The second are generally serviceable for prop-wood, fencing, farm-stackyards, and other purposes.

All timber should be cut down as soon as maturity is arrived at, in order to prevent loss during gales, after which the market is often overstocked with fallen wood. Hence whenever it is considered that the interest on the money to be realised will amount to more per annum than the trees will add to their value if left standing, felling ought to be proceeded with. Ornamental plantations are also susceptible of being uprooted through severe storms. In order therefore to maintain a succession of trees, all open spaces should be immediately planted with deciduous and evergreen species, such as oak, sycamore, ash, beech, lime, chestnut, larch, common silver fir, *Picea nobilis*, *Picea grandis*, *Abies Douglasii*, *Thuja gigantea*, and others; and in many instances it is admissible to cut down matured larch, fir, and spruce, and to substitute young trees in their stead.

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[1] This is equivalent to a crop of about 300 per acre.

THE PLANTING OF GROUND WHERE TIMBER HAS RECENTLY BEEN FELLED.

As trees approach maturity, seedlings germinating from the fruit of old trees generally make their appearance, especially where the surface of the ground is covered with heather; and where such is the case grazing animals should be strictly excluded, and the fences kept in thorough order.

For the exclusive purpose of natural reproduction, however, mature timber should not be left standing, although hardwood standards, and in some cases groups of conifers, may be allowed to remain at judicious intervals, for the sake of appearance, provided that they are in a state of perfect health.

Natural seedlings rarely produce a uniform crop over all the ground, and where blanks have to be filled up in places where the old trees stood closely, pits from twelve to eighteen inches square, of sufficient depth, and about four and a half feet apart, should be made at least six or eight months before the plants are inserted. These ought not to be left open, but the soil taken out in forming the one should be placed into the other, as the ground is in this way loosened and rendered productive. The seedlings used ought to be twice transplanted. Although failures frequently occur by notching plants into such ground, this is to be expected, when it is considered that most of the soil is so firmly bound up with the old matted roots as partially to deny the young trees the sustenance and nourishment indispensable for their vigour and health.

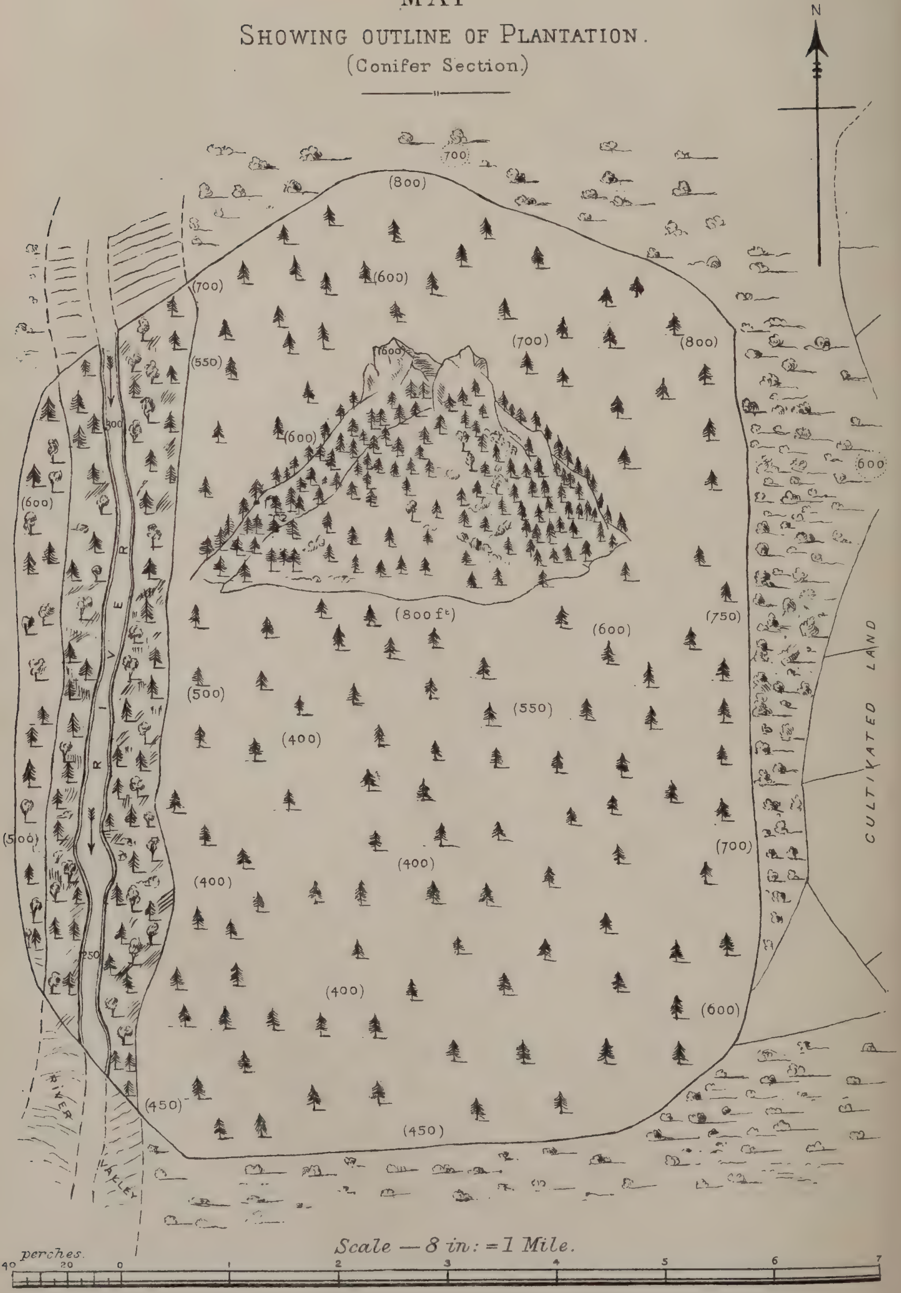
Oak and other coppice-wood, in many districts, is no longer a profitable forest crop, since bark has fallen so low in price. Where it is unremunerative to bark the trees, the smaller-sized and inferior coppice-wood ought to be cut out, the best trees being alone reserved as standards, at distances varying from fifteen to twenty yards. The ground should be replanted with larch, *Abies Douglasii,* common silver fir, *Picea grandis, Picea nobilis,* and other profitable trees.

Pl. V.

MAP

SHOWING OUTLINE OF PLANTATION.

(Conifer Section.)



Scale — 8 in: = 1 Mile.

IV.

THE FORMATION AND MANAGEMENT OF PLANTATIONS ON DIFFERENT SITES, ALTITUDES, AND EXPOSURES.

By Richard Edmond Hodson, *Hollybrooke, Bray, Co. Wicklow, Ireland.*

Site, altitude, and exposure being points to be carefully considered in this Essay, the character and formation of the ground which it is proposed to lay out may be briefly explained at the outset.

This ground, which is about one square mile in extent, is undulating in general character, and varies in elevation from 400 feet to 800 feet above the level of the sea. In its centre a hill springs abruptly to a height of 800 feet above its general surface, and in addition to this hill, on the east side of the ground selected, a ridge runs approximately north and south, against which abuts cultivated land which must not be interfered with. On the west, a considerable valley, through which a stream flows, runs due north and south, while on the north the ground is rough and broken. Plate v. gives an idea of the ground and its arrangement.

Though the occasion to form a plantation at greater elevations than 1600 feet may often arise, such work, where profit is the ultimate object, cannot be recommended in these latitudes, as even at this height much will depend on the nature of the soil, and on its suitability to those varieties of trees which the planter may select.

In the present case the soil varies from a good loam in the valleys to a rough detritus on the hillsides, and comprises between these extremes certain portions of sandy loam, gravelly clay, peat, and wet bog, the whole producing a growth of coarse grass, heath, stunted gorse, and bracken—such a combination being not uncommon on ground that is selected for plantation-work.

In the sequel it is proposed to treat of the coniferous and hardwood sections separately, but it is to be understood that cone-bearing and deciduous trees may be planted together on fitting occasions, and under such conditions as will be recorded below.

A. CONIFEROUS SECTION.

Outlines and Boundaries.—In deciding on the outline of any plantation taste and judgment are required, but the great desirableness of combining something of the beautiful with the useful should never be lost sight of, as charming effects may be produced by a little forethought, without in any way detracting from the profit likely to accrue.

Many considerations must necessarily tend to determine the position of boundaries, and point out the directions in which it will be found most desirable to plant. Thus the existence or future probability of modes of transit, such as a proposed new railway, road, or canal, are of great moment, while distance from or proximity to public roads, or bounds of property and public right of way, are no less significant factors.

Boundaries must, however, be laid out, in the first place, with a due regard to the shelter to be afforded to cultivated land in the neighbourhood, and to the plantation itself, and, as far as possible, a line of higher elevation than the body of the proposed forest should be selected. Although square plantations do very well on fairly level ground, where all the sides are pretty equally exposed, it is to be borne in mind that along continuous straight lines of trees high winds will exercise their full destructive force. Hence it becomes necessary to blend one curve with another, so as to place an obstruction to check or weaken their full power at one spot, while it is often expedient to fine out the plantation to a point at another. The form of the outline, moreover, ought to be regulated by a due regard to the prevailing wind, and should present a convex side towards it, as it is obvious that on striking such a curve, a storm would expend itself in two opposite directions, and thereby lose at least part of its destructive power.

On the western side, and along the further or western brink of the valley, space should be left for a substantial belt of trees to act as a wind-check (after the manner of a breakwater), so as to prevent gusts as far as possible from reaching the corresponding point across the valley, where the plantation proper may be said to begin. To the north a triangular form should be adopted, if the formation of the ground will admit of it, but in no case should the most northerly point, or the apex of the triangle, be located in a hollow, or even on low ground, as this would obviously do away with all the advantages to be derived from such a figure. Along the eastern ridge a curve or even a straight line may be adopted, but the plantation must be limited in this direction by the elevation already referred to, or in its absence by an undulating line, all marked indentations into which a high wind might force its way among the tender stems being carefully avoided.

At an early stage it is desirable to select a suitable site for the erection of a *saw-mill* and *timber-yard*. Water-power should if possible be secured for the former, and the latter, which must be in its immediate vicinity, should be within easy reach of a good road.

PREPARATION OF THE GROUND.

Having finished the marking out of the boundaries, *fencing* must be commenced. If stones are plentiful, a stout stone wall, built " dry," or without mortar, and supplied with a heavy rough coping of mason-work, is to be recommended; if only abundant, a bank faced with stone—the ditch from which the bank is formed being on the side away from the plantation—may be constructed, as such a fence, when not built too perpendicularly, is very durable, and affords excellent shelter. In cases where stones are very scarce, a deep ditch and stout bank planted along its side with the common white and black thorn, or with dwarf beech, will be found very suitable. Posts and rails, or wire fencing, on the other hand, afford little or no shelter, and are at the same time very liable to be damaged by cattle and falling trees.

While the fences are being constructed, or as soon as the outline of the plantation has been determined, if a sufficient number of workmen is available, the preparation of the ground may be commenced. With regard to this work much difference of opinion exists. Some affirm that a deep trenching and a thorough stirring up of the subsoil is almost a necessity, while others recommend (but this is more in connection with hardwood plantations) a course of tillage—*e.g.* a crop of turnips eaten off by sheep—as a suitable preparation for the soil. It is almost needless to add that, in plantations of such magnitude as are usually undertaken nowadays, such preparations are simply out of the question.

Much has been said for and against the removal of grass sod from the site of proposed young forests, but all things being considered, the practice cannot be approved of. Similarly, the coarse herbage which exists on the selected ground should not be indiscriminately removed, as it may prove of inestimable value under certain conditions. In all low and sheltered positions, on certain sections of level ground, and to a certain extent on southern and western slopes where such a rough growth occurs, and would be likely to gain the ascendency, fire will perform all necessary clearing work, and will serve a double purpose, in at once destroying the objectionable vegetation, and in supplying the surface with a valuable vegetable manure in the form of ashes, by which the future crop will be benefited to no small degree.

In all exposed situations, on the other hand, the growth of heather or rough grass will be less luxuriant, and will prove of very great advantage, chiefly on northern and eastern aspects, as a shelter to the young plants, hence in such cases the removal of such a growth would be highly detrimental. Moreover, it may be noted that the power of young forest-trees to exist and succeed amid a surrounding growth has probably been underrated hitherto.

A most important item in the formation of a plantation is its efficient *drainage.* In this work every fall of the ground must be taken advantage of, and in many cases much may be done by straightening and cleaning existing water-courses. There may be many acres where not a single conduit need be cut, and the fault of overdraining must be guarded against to the same extent as its opposite extreme.

In commencing the work the position of the main outlets must first be determined, with a view, if possible, to utilise the surplus water in the way of aiding in the formation of boundaries. The main drains are next opened according to the fall of the ground, and minor conduits are formed up and down the face of the slope where it is a moderate one, but diagonally if it is steep or precipitous, so that the moisture may not be drawn away too speedily, and carry with it the most valuable particles of surface soil. It is impossible to lay down rules as to the exact number and dimensions of drains, as these must depend altogether on the condition of the soil through which they pass, the amount of rainfall to be carried away, and the class of trees intended to be benefited thereby. It may however be suggested that no minor drains should be more than 35 feet or less than 10 feet apart; while their extreme dimensions should vary between 24 and 36 inches in width at the top, 10 and 18 inches at the bottom, and 18 and 28 inches in depth. The largest amount of water ever likely to be carried into them by the minor drains must be a guide in deciding the dimensions of the main leaders. In all cases the sides of the water-ways must be allowed an easy slope, so as to prevent falling in and consequent obstruction, and to allow of their being thoroughly and easily cleaned when necessary, but covered or pipe drains should be in no circumstances laid down on account of their expense and liability to become choked or otherwise disorganised.

In very moist situations or boggy patches, the system known as "the herring-bone" may be adopted with advantage, and occasional short "spur" drains, to tap the source of a spring or draw off the moisture from an isolated spot, are often useful.

For the escape of the surplus water, openings formed of large stones or mason-work, and varying in size according to the amount of water to be carried away, should be constructed. These should be supplied with a strong grating, provided with bars, arranged vertically to the flow of the water, and this, instead of being bedded in the mason-work, should be hung on a pair of pivots, or swung from a few inches of light chain. In this way the liability to become choked and clogged will be less, and when any tendency in that direction occurs, the accumulation of water will force the grating open, while its weight will restore it to its former position after the obstructing material has been swept away. In some cases waste water may be conveyed to a reservoir, and stored for the purpose of supplying a fixed or portable saw-mill.

A most necessary work in the formation of a plantation, and one which will add materially to its value, is *the construction of roads.* The direction of these ought to be determined early, or at any rate before the lie and formation of the ground is concealed by the crop, although it is not essential to lay them down permanently at this stage. Such work may be carried on when the weather becomes unsuitable for planting operations. It is very desirable to lay down substantial well-constructed main roads once for all, so as to prevent subsequent repairs, which often become a surprisingly large item in the charges coming under the head of Management.

The width of such main roads, a foundation for which should be excavated and made up with broken stones, should be 18 feet, inclusive of side drains and narrow margins. The surface should be " barrelled " in order to permit water to run off into the side channels, and substantial bridges or culverts should be constructed where necessary.

In large plantations growing on level ground, parallel roads at suitable distances, or converging to convenient points, are much to be desired, but on hilly and broken ground the conformation of the place must be taken advantage of in every possible way, and the greater ease with which timber or any other weight can be conveyed down hill than up is ever to be borne in mind. Hence, so far as possible, the roads should run along hollows and valleys. In many cases, however, such a course cannot be carried out, and as easy gradients as possible must be formed across the face of the valleys or hillsides. Their position should be so arranged that they may converge to suitable points for unloading and sawing work, while at the same time they should occupy the least possible space and cover the least possible distance.

No opportunity should be lost in utilising the formation of the ground for the construction of slips for the transport of timber wherever practicable—as for instance on the almost precipitous slopes of a hill-side, where the construction of roads would be attended with great expense—as such means of transit will prove most valuable; moreover, these slips, besides being easily constructed, require little or no attention, timber being required only in very exceptional cases.

Minor roads, for the removal of thinnings, need not necessarily be laid down until the time for that branch of management arrives, but their future course should be determined before the inequalities of the ground become concealed from view. In cases of moist springy ground, difficult to drain, a substantial roadway may be formed by placing a layer of timber posts of requisite length at right angles to the direction of the road, and in close proximity to each other, such waste brushwood as may be found at hand being placed upon and between them. This operation is known as "corduroying."

At the points where it is found most convenient for the roads to emerge from the plantation, stout mason-work piers should be constructed, and on these light iron gates, which are at once neat, durable, and economical, should be hung.

In the case of large plantations a survey and map should be made, as this will always prove interesting, and sometimes of great subsequent value.

OPERATIONS CONNECTED WITH PLANTING.

In the planting of forest-tree seedlings the method of "pitting" or of "notching" may be adopted, but the practice of sowing the ground with seeds is to be disapproved of in such plantations as are now being described.

Although each of the above methods has its warm supporters, the former is in most cases to be preferred; but much depends on the nature of the ground. Should this chance to have been prepared by a course of tillage, or by a former crop of timber, notching will, no doubt, prove successful; but it seems unreasonable to expect a tender young plant to thrive on being forced into a slit (for it amounts to this) in such barren ground as is often set apart for plantation purposes. In such circumstances, a one-sided growth, arising from the fact that all the roots have been laid and securely fixed in one and the same direction, may often be seen, and the existence of an unnatural curve at the base of the stem, reducing the value of the heaviest and otherwise most valuable portion of the tree, is not uncommon.

On the other hand, the advantages of "pitting," if properly performed on ground hitherto uncultivated, cannot be questioned. The pits should be opened some months at least before planting is commenced, so as to allow the earth which has been removed to lie exposed to the mellowing influences of the sun and atmosphere, so that when the time for replacing it about the roots of the young plants arrives, it will be reduced to a friable and porous state. This will allow any valuable chemical properties it may possess at once to act upon and give a start to the delicate rootlets, which by the other method would tend to be compressed in a mass of cold unyielding substance, impenetrable "pan," or injurious subsoil. In the case of tenacious dense clay, precautions must be taken to guard against its being transformed into a brick-like substance while lying exposed to the sun's rays.

It is not, however, to be understood that though the "pitting" system is preferable, the "notching" method is to be discountenanced. On the contrary, on precipitous slopes, or on rocky and uneven ground, the latter plan will often be the only one feasible; and forests thus planted have often succeeded admirably.

The *selection of suitable trees* for an ultimate crop is a very important matter, as upon this choice the secret of the success of the forest will depend. Of late an enormous number of new, and so-called "improved," species of Coniferæ, chiefly imported by means of seed from America, have been, and are, daily being put before the public; and it is apparently becoming the rule to accept all that come, to plant them indiscriminately, and to take it for granted that they are suited in every respect to our climate, and to the different conditions to which they must necessarily be subjected. That this is a dangerous practice cannot be doubted. It is true that some of these varieties will succeed, and others may do so for a certain number of years; but the wholesale acceptance of untried varieties will, in the end, prove a failure. Moreover, from the point of view of profit, it is hardly necessary to go beyond the collection of well-tried, valuable, and acclimatised Coniferæ which is already at the planter's command.

Local manufactures and local demand ought always to influence the selection of timber, but as these vary with every district, no fixed rules can be formulated.

TREES SUITED FOR VARIOUS POSITIONS.

As to the distribution of seedlings over the ground, it has been well said that there is nothing so dangerous as obeying too servilely the directions given in books. No absolute laws can be laid down on this matter, but experience has proved that certain classes of trees prefer certain soils, certain aspects, and certain formations of ground. A large proportion of our most valuable Conifers are not, happily, too fastidious in this matter. Although, in the case of the larch, heavy losses have been incurred during the last few years, owing to its failure, it is probable that in future plantations this misfortune may be obviated in a great measure by paying more regard to the nature and habits of the tree. It delights in an elevated situation, and in a dry, somewhat sandy, and porous soil. On the other hand, strong dense soils are most unfavourable, creating an abnormal growth, upon which late frosts act most injuriously. The misty atmosphere of sheltered valleys and low lands, as well as stagnant water, have proved particularly fatal, nor is excess of running water less injurious.

Planting may be successfully carried out during all open weather from the end of September to the beginning of April, and the most suitable age at which to transplant seedlings into the forest will be at the close of their third, or commencement of their fourth year, when they vary from ten to twenty inches in height. The seedlings should remain two years in the nursery after transplantation from the seed-bed.

In the removal of plants from their nursery, care must be taken that the roots and tender rootlets are not injured by rough usage or by exposure to the atmosphere. The supply should always be regulated by the demand, but should it be necessary for the plants to remain out of the ground for any considerable time, they ought to be carefully shaded, and protected as far as possible from injurious influences.

Numerous experiments, carried on in Germany and elsewhere, have almost conclusively proved that in planting pine woods the distance of three feet from tree to tree produces the largest yield of timber per acre. On account of the acknowledged humidity of the British Isles, a strict adherence in all cases to this rule is not advisable, but it should be followed where land of moderate quality and elevation exists. In the laying out of shelter belts, six, or even twelve inches, less will not be excessively close in very exposed positions, or on bleak mountain-sides, where the soil is shallow and the root-hold uncertain. On the other hand, in deep loam, or in any rich soil in sheltered valleys or lowlands, where the growth will be rapid and luxuriant, the young trees should be set at a proportionately greater distance apart.

Among the many advantages that accrue from the existence of shade afforded by trees, it may here be remarked that the natural, equal, and timely decomposition of fallen leaves, which provide a most valuable "humus," and by means of which even the most barren soil in the lapse of time becomes fertilised, is among the most important, while the disintegration of the soil, which is essential for the healthy growth of wood, is rendered more uniform.

The south-west boundary of the plantation—which is, in the present case, supposed to face the prevailing wind—should be planted closely with the Scots and Austrian pines, in the proportion of two of the former to one of the latter, and from ten to twelve rows deep. Here also, along the outer edge, a few sycamores and Norway maples may be introduced in order to vary the outline and assist in sheltering the interior.

Along the west boundary, stretching along the brow of the valley, the Scots pine, in conjunction with the spruce, Weymouth, and cluster pine, may be placed along with a few hardwoods, such as sycamore, Norway maple, and ash. On the slopes of the valley the beautiful silver fir will succeed admirably, while the upper portions may be clothed with the Scots, cluster, stone, and Corsican pines. At a lower level, any ornamental specimens—such as *Wellingtonia gigantea*, *Cedrus deodara*, and *Cryptomeria Japonica*—will flourish vigorously, but nurses of Scots pine and spruce fir should be employed at the outset, although they must be removed when overcrowding occurs. Some deciduous trees, moreover, such as the British oak, the ash, and the alder, will not be out of place —the two last named, when planted by a stream, securely "binding" its banks, and checking the wearing influence of floods. On the comparatively sheltered portions of the slopes, the beech, elm, and sweet-chestnut are certain to succeed and prove valuable.

Along the northern boundary, the Scots pine, mingled with spruce, larch, and the cluster and Swiss pines, in the proportion of two to one, should be planted, in order to form a substantial shelter from the piercing north winds. The outer belt should be as even and dense as possible, so as to prevent chilling blasts from penetrating and causing a bark-bound and stunted growth, and in all cases, hardy and well-grown specimens should be selected for shelter purposes.

On the straight eastern margin, the Scots pine, planted with the spruce, Austrian pine, black spruce, and Swiss pine, in the proportion of one to two, will thrive well.

In the body of the plantation, if the nature of the soil will produce valuable timber, this should be planted to the exclusion of other less valuable wood. Thus larch should be preferred to Scots pine or spruce—even thinnings of the first named being of greater value than those of the others. In somewhat moister and more peaty ground, larch and Scots pine may be placed in the ratio of one to two, and in such areas the Corsican pine, the value of which has not hitherto been fully recognised, will also succeed. This last species is admirably suited to our climate, and the desirableness of planting it extensively, in conjunction with Scots pine and spruce, the latter to be thinned out when necessary, cannot be too strongly advocated. A south-east aspect will be found most suited to its requirements, and it has been successfully planted along the sea-coast.

In moist and somewhat boggy ground, the Scots pine and black spruce, in the ratio of two to one, will flourish. These should be planted at somewhat wider intervals in order to allow a fuller development of side branches, whose leaves assist in removing stagnant moisture, and also that the sun may more easily strike upon and dry the surface. For very swampy situations, where drainage may be impracticable, the black spruce, the swamp pine, the balsam fir, and *Thuja gigantea* will prove invaluable, but should any difficulty occur in procuring such seedlings, they may be replaced by hardwoods, such as the different varieties of the poplar and alder.

Upon the lower slopes of the hill—say up to a height of 1100 feet—any of the varieties already mentioned will succeed, and preference should be given to those possessing the most valuable timber.

Generally speaking, the Scots pine should not be planted to any great extent on a south or south-west aspect, as a too speedy growth is thus induced, causing the decay of the timber before it arrives at maturity. As a northerly exposure is most favourable to its normal development, the higher ground should be planted with it on that side. It may also be employed on the eastern aspect above the elevation of 1200 feet or 1300 feet, and it may here be mingled with Swiss pine and black spruce. On the south-east it may be planted along with a few Corsican pines and larches, and considerable clumps of birch, mountain ash, and perhaps a few Norway maples, which are likely to succeed admirably, and will add in a great measure to the beauty of the whole.

On the elevated ground to the south, south-west, and west, larch, spruce, and Corsican pine may be placed, even to the highest point of the ground, but some Scots pines may be added for the sake of shelter.

In the formation of *shelter belts*—the significance of which cannot be over-estimated, inasmuch as, in exposed situations at least, the success of a young plantation depends on the artificial shelter afforded it—planting in lines should be avoided.

When these belts are formed on the sea-coast, the outer margin may be formed by a dense hedge of sea-buckthorn. Next to this, the sycamore, mountain ash, elder, birch, holly, and the spurge laurel will grow well, while the privet, barberry, and the common gorse will be of use. Conifers, such as the cluster pine, which will flourish in pure sand, and the Austrian and Corsican pines, may be added with advantage. *Cupressus macrocarpa* has also proved itself to be of value in such exposed positions. It is to be noted that the plants which are indigenous to the district should have the preference in forming such belts, and all trees should be planted at an earlier age than would otherwise be the case. Thinning, when necessary, should be very judiciously carried out, as openings or gaps will prove most injurious.

In a moist climate the subject of *fire lines*, although one of extreme value in warmer and drier latitudes, is of little moment, and it may merely be noted that such hardwoods as the alder, walnut, hornbeam, and poplar can always be depended upon as suitable for such lines.

EARLY GROWTH.

During the first two years subsequent to planting, the growth of the seedlings will not be very perceptible, each being employed in establishing itself in its new home; but all ground game should be well kept down, or altogether exterminated, during this period, all fences should be well attended to, and all gates kept securely locked.

During the next eight or ten years little labour will be required in the young forest beyond the securing of such plants as may have been loosened by the force of the wind, the cutting away of injurious weeds, the replanting of fresh seedlings in cases of failure, and the removing of any overpowering growth of natural grasses or heath.

Pruning is not, in the case of pine forests, a very costly or important item, as the shade produced by the upper causes the decay of all lower and, as far as the healthy development of the tree is concerned, valueless branches.

Upon the work of *thinning*, on the other hand, wide differences of opinion exist, and as the periods at which thinning becomes necessary altogether depend upon the varying nature of the soil and the suitability of the latter to the particular kind of seedling that has been planted in it, no fixed rules can be laid down. The varying sites, altitudes, and exposures, too, occasion an unequal growth, and add to the uncertainty in this case. It must, however, be clearly borne in mind that this work is to be performed in such a manner as not to reduce the value of the crop, but so as to tend to the production of the greatest quantity of the most valuable timber in the shortest possible space of time.

About the ninth or tenth year of the life of the plantation it should be examined, for the purpose of relieving cases of marked overcrowding, which will probably be most noticed in the lower and more sheltered portions, and of removing obtrusive side branches or contending leading shoots.

In large plantations, where each individual tree cannot become an object of the forester's attention, the suppression of ground game and the prevention of trespass become of the highest importance.

About its eighteenth or twentieth year the young wood should be carefully thinned in its most crowded parts, and the poles cut down will now be found suitable for various economic purposes.

In many cases a general thinning may be found necessary about this period. Autumn will be the most suitable time to begin the work, as the trees will become accustomed to a freer circulation of air, and no sudden check to the growth of the tender spring shoots will take place.

Thinning should be commenced at the most central point of a plantation, or section of a plantation, so that the outer intact boundary may continue to form a barrier to cold blasts, which would seriously injure trees hitherto standing in close order. In moist ground particular care must be taken not to create too wide gaps, so that the surrounding trees may not be laid low by the wind. All deformed or weakly trees, and those never likely to be of much value, should be among the first to be removed.

The periods of all future thinnings must depend upon the condition of the trees. Sufficient light or air should be allowed, to prevent them from becoming drawn up and "lanky;" but too much space should not be given, inasmuch as a too vigorous growth of side branches will occur—a circumstance which will detract from the ultimate bulk and value of the timber.

In many cases a great demand for light timber, such as young fir and larch poles, exists, and where this occurs, it is advisable to plant a succession of crops, and thus create the necessity for continuous thinning. In other cases, after the age of twenty years, from six to eight general thinnings may be undertaken before the final removal of the crop, and these should be so ordered that, between the seventieth and eightieth years, when the greater portion of Coniferæ may be cut to the most advantage, from 160 to 200 trees remain to the statute acre.

Felling may be most successfully performed between the months of September and February, and bark-stripping should be carried on during the summer months.

The following cone-bearing trees are to be recommended for afforestation work, as they are at once valuable and well adapted to our climate :—

Pinus Austriaca (Austrian Pine).
Picea balsamea (Balsam Fir).
Pinus pinaster (Cluster Pine).
Pinus laricio (Corsican Pine).
Larix Europæa (Larch).
Pinus sylvestris (Scots Pine).
Abies pectinata (Silver Fir).
Picea nigra (Black American Spruce).
Picea excelsa (Norway Spruce).
Picea alba (White Spruce).
Pinus pinea (Stone Pine ; not hardy).
Pinus tæda (Swamp Pine).
Pinus cembra (Swiss Pine).
Pinus strobus (Weymouth Pine).
Abies Douglasii (Pseudo-Tsuga).
Abies nobilis.
Abies Nordmanniana.
Cedrus deodara.
Cedrus Libani.
Cryptomeria Japonica.
Cupressus macrocarpa.
Cupressus Lawsoniana.
Pinus contorta (scarcely hardy).
Pinus insignis.
Pinus monticola.
Thuja gigantea.
Wellingtonia gigantea.

B. HARDWOOD SECTION.

Here the ornamental planting of deciduous trees, which comes more within the province of the landscape-gardener than the forester, may be left out of consideration, and many of the operations already described apply, with slight modifications, to this class of wood. While the pine is essentially a mountain-loving tree, hardwoods delight in localities where greater depth and richer quality of the soil afford at once a sounder root-hold and a more congenial medium through which the wide-extending roots may draw their nourishment.

For our present purpose let us imagine that the ground to be planted with hardwood consists of an undulating stretch of land, varying from 100 to 500 feet above sea-level, including a variety of sites and exposures, and composed of soil varying, according to the formation, in depth and quality. On such a site, profit, and shelter to surrounding lands, and to the plantation itself, may be combined with great ornamental effect.

In the marking out of boundary lines, every advantage should be taken of the undulating character of the ground. As already indicated, an elevated portion of the area may be utilised in forming a limiting line, and where any considerable valley exists, the brow furthest from the plantation should be planted so as to break the full force of the wind, and prevent damage to the main body of the forest. It is especially to be remembered that the more compact a plantation is made, the greater will be the shelter and warmth it affords, and the less the amount of fencing it will require. Straggling lines or belts should be particularly avoided.

It is, moreover, to be noted that in the present case larger and deeper drains, at less frequent intervals than have been recommended for coniferous forests, should be constructed, but at the same time over-draining, which adds to the expense and involves the wasting of valuable space, as well as a reduction in the ultimate value of the crop, must be guarded against.

CONSIDERATIONS BEARING ON PLANTING.

In planting, the method of forming pits for the seedlings is much to be preferred to that of notching. Moreover, hardwoods should not be planted out until they have arrived at an age and consequently a size, at which notching would be obviously unsuitable.

It should also be carefully remembered that great service may be rendered to the seedlings at an early age by a judicious pruning of the head, and by the shortening or removal of one-sided or unequal roots, as in this way the laborious operation of subsequent pruning may be reduced to a minimum.

For the purpose of forming a margin to the young forest, the wind-resisting or sheltering powers of the trees must be carefully considered. In this respect the sycamore, horse-chestnut, and ash, planted at about twelve feet apart, will prove valuable; the maple, too, and a few beech and sweet-chestnut, if there be a fair depth of soil, will assist in forming a stubborn breastwork against dangerous storms or sudden blasts, and will add materially to the beauty of the outline. These should be interspersed, at distances of three or four feet, with the Scots pine, the cluster pine (particularly in sandy soil), and a moderate proportion of spruce fir and larch as nurses for the hardwoods, especially as in cases of failure these shelter trees may remain with advantage.

In deciding upon the different varieties of trees to be planted, and upon the relative proportion of each of those varieties, the respective value of their timbers, the local demand or manufactures, the rate of growth, and the probability of increased value in the future, are considerations of great importance, while the nature of the ground and its suitability for particular species must never be lost sight of. The folly of planting a valuable tree in an uncongenial soil, while others, less valuable indeed, but thoroughly suited to it are at hand, is at once apparent; and in all cases healthy, well-grown, and vigorous seedlings should be selected.

The species likely to prove most profitable are the British oak, ash, sycamore, beech, alder, elm, poplar, and the black American walnut, which is likely to become a source of profit in the near future.

As hardwoods require a greater space than conifers for their proper development, they must be planted at greater distances apart, and as warmth and shelter *must* be supplied, the method of planting coniferous "nurses" has been resorted to with admirable results. To plant hardwoods themselves for purposes of shelter, and for removal when occasion may demand, is unprofitable. In putting down coniferous nurse-trees, it is to be borne in mind that they should never be planted save when absolutely essential, as at the age at which, for the welfare of their hardwood neighbours, it becomes necessary to remove them, the slight poles then formed are of little value.

In most cases, although many strongly advocate the method of indiscriminately mingling hardwoods in afforestation work, groups or divisions of the same varieties should be laid down, a practice which fully concurs with that of planting given species in a given kind of soil. As a rule, trees flourish best when they grow beside others of their own species; moreover, since all trees do not arrive at maturity or at a valuable age in the same time, and since their requirements as to space and light vary according to their varieties, many cases would arise in which a choice would have to be made between unsightly and injurious gaps, or scanty head-room and deteriorated timber.

If, however, different trees resemble each other in the manner of their growth, or arrive at maturity about the same period, or agree in their requirements of space, light, and soil, they may be readily grouped together.

In the case of all our hardwoods, the most suitable time for transplantation in the forest will be when the seedlings are from two and a half to four feet in height, although some varieties, such as the elm and poplar, may be safely moved at a much greater size. All open and moist weather between the end of September and the beginning of April may be taken advantage of for planting work. All seedlings should be carefully raised and replanted without delay, in order to prevent exposure of the roots to the atmosphere; and great care should be exercised in securing them firmly in the ground, as a great proportion of failures arises from the destruction of tender rootlets consequent upon the swaying motion of the upper portion of the tree. Water will readily lodge in the opening at the base of the stem formed by such motion, this will pass to the roots, and should a severe frost occur the death of the plant will certainly follow.

In deep and rich soil the black walnut may be cultivated with advantage. In the case of this tree it has been found that planting in the position in which the tree is intended to remain is a more successful method than transplanting from a nursery. The "nuts" may be placed at a distance of four feet apart, and covered to a depth varying from one to two inches, autumn being the most suitable time for sowing. The method of transplanting need not, however, prove unsuccessful, and it will no doubt in the end be more economical, as the close and prolonged supervision of forest ground which the former method of cultivation involves, will add considerably to the expenses of management.

Along the course of streams in moist or boggy patches, there may be placed with certain success the black poplar, alder, or white poplar, and should suitable ground for an osier bed, and a ready sale for its produce exist, its formation is to be recommended. For this purpose the crack willow (*Salix fragilis*), the common white willow (*S. alba*), the golden willow (*S. vitellina*), the dark-leaved willow (*S. nigricans*), and *Salix triandra*, may be selected, but they will not succeed in stagnant water.

On the slopes, where there is a moderate depth of fairly good soil, the oak will thrive; the elm too, should such positions be sheltered from prevailing winds, may be planted here with success, as well as the beech, sweet- and horse-chestnuts, wych elm, and ash, all being set at distances varying from twelve to fifteen feet apart.

Upon the upper portions of the slopes, and on all higher and more exposed ground, nurses of larch, Scots pine, and spruce may be employed. Of these the larch should stand next to the hardwood, as it admits of a freer circulation of air, and by the pruning of overarching side branches the removal of the nurse itself may be delayed until such time as it can be disposed of with advantage. On comparatively level ground, if the soil is of a lighter and more gravelly nature than that already dealt with, and if the elevation and exposure are greater, planting should be somewhat closer than in the hollows, while on the brows, and on much exposed situations, hardy conifers may be introduced to a considerable extent. On ground of moderate elevation a successful mingling of varieties may be effected, and on all south, south-east, and west aspects, the beech, chestnut, wych elm, lime, ash, sycamore, and poplar may be planted, the proportions of each variety being decided upon by its relative value and local demand. For most of these from nine to fifteen feet apart will be a suitable distance, but in this matter the nature of the soil must in a great measure be a guide to the work. The poplar, alder, and birch (when employed) may be planted considerably closer than the distance above mentioned, and all nurses should be placed at from three to four feet apart.

To the north and north-east, and on all elevated and exposed situations, in addition to conifers, the hazel, hornbeam, birch, wild cherry, and mountain ash will grow, and for purposes of shelter and warmth, the holly, laurel, elder, privet, common yew, and suchlike, will prove of service, the preference being in all cases given to plants indigenous to the district, and to the varieties for which there may be any special local demand.

The following is a brief summary of the best soil adapted for some of the more common species of hardwood :—

Alder.—A damp rich soil, in proximity to water if possible.
Ash.—Chalky loam to be preferred, but it will succeed in shallow soils and in exposed positions.
Beech.—A fairly deep chalky soil.
Birch.—Upland slopes ; it will succeed at great elevations.
Chestnut (*Sweet*).—A deep sandy loam.
Chestnut (*Horse*).—A deep firm loam (timber of little value).
Elm.—A deep dry loam, in sheltered positions.
Hazel.—Chalky loam ; it will grow at considerable elevations.
Hornbeam.—A hard clay soil.
Lime.—A deep firm loam.
Maple.—A dry gravelly soil (it is valuable for cabinet-making).
Mountain Ash.—A gravelly loam.
Oak.—A deep substantial loam.
Poplar.—A rich moist soil to be preferred, but it will succeed in most soils.
Sycamore.—A rich porous loam to be preferred, but it will succeed in most soils.
Wych Elm.—A good loam.
Walnut.—A rich, well-drained, chalky soil.

COPPICE.

Opinions vary so much as to the desirableness of planting coppice or underwood in conjunction with hardwoods, that it may here suffice to state as concisely as possible the advantages and disadvantages attending such a growth. Independently of its market value, it will aid in the preservation of game, and may prove useful as shelter in exposed situations, while it will at the same time add to the beauty of the whole. On the other hand, the roots of the underwood deprive those of the hardwoods of their due amount of room and nourishment, and tend to prevent air from circulating both through the soil and about the stems; nor can the fallen leaves, though of acknowledged value, become either fairly distributed or naturally decomposed. Although the pecuniary advantages to be derived must altogether depend on local requirements, in most cases such growth is not to be encouraged.

PRUNING.

The object of pruning is to afford to each individual tree sufficient light and circulation of air to meet its requirements. Its growth should be directed into such a form that when the tree arrives at maturity its most valuable portions may be found to be those most fully developed; but in this the natural tendencies of the tree must be taken into account, and the desire to produce the greatest possible amount of the most valuable timber must be tempered by the knowledge that a due proportion of branch, twig, and foliage is absolutely necessary for its healthy development. The shade occasioned by the existence of trees in close proximity will, to a certain extent, cause the decay of the lower branches, and so assist materially in this operation; yet the work must be regarded as a necessary branch of forest management.

That pruning may be successful, it is advisable to look over the plantation about the fourth or fifth year of its existence, and to correct cases in which irregular, unnatural, or one-sided growth is observed. This should be repeated during the early years of its development as often as occasion requires, so that by attending to the form of the saplings from their youth, the necessity for the removal of heavy boughs may be entirely obviated in their more advanced stages. Should it become necessary, under any circumstances, to prune a plantation composed of "heavy" timber, the large boughs should first be shortened, so as to prevent havoc in their fall; and then the remainder should be cut as close to the trunk as possible. In this way a healing process will immediately begin, and the surrounding bark will soon close over the wound, leaving only a very slight mark to indicate the former position of the branch. In all cases where large boughs have been removed, a dressing of common clay applied at once to the wound will prove of service as a protection against atmospheric influences.

August, September, and the first fortnight of October, is the most suitable period for carrying out pruning work, as, the sap being then on the descent, great "bleeding" is averted, and the wounds will have healed to a certain extent before the commencement of the following spring growth. At any rate, the autumn are to be preferred to the winter or spring months; for in the one case, frost and excessive moisture will prove injurious; in the other, in addition to the loss of sap alluded to, an unsightly and useless bushy growth will often spring from the neighbourhood of the edges of the incision. It must be carefully borne in mind that pruning should never be performed to any extent immediately before, or immediately after, any considerable thinning.

When hardwood is planted for the purpose of shelter, or of acting as a screen to conceal unsightly objects, the greatest possible development of branch and foliage should be aimed at. On the other hand, in the cultivation of "valuable timber," when rival leading shoots exist, the one most perpendicularly over the bole should be retained, and others, however robust or promising, should be removed as close to the stem as possible. The tree must be equally balanced, and the boughs where they spring from the trunk should be equally distributed. Any heavy, ungainly branches, springing from the upper part, and manifestly out of proportion to the surrounding growth, or to the tree itself, should, if the plant is young, or one in which, in all probability, a gap would be shortly replaced by the surrounding growth, be at once removed as close to the trunk as possible. This may be done by first giving it an "under-" or "up-cut," and by finishing from above with a clean incision, so made as to slope inwards from above, and then outwards, in order to prevent all lodgment of water and consequent decay. Should such a bough exist at a lower level on the stem, and be supplied with three branchlets or divisions, two of them may be removed and the third shortened. When two large boughs spring from the trunk in close proximity, the one being perpendicularly over the other, the entire removal of one will probably be desirable; or if a lower bough, springing at right angles to the trunk, be found to curve and become parallel to the latter, it should be removed *early*, inasmuch as, if left, it would detract from the growth and vigour of the parent stem, and would, at the same time, destroy the symmetry of the tree, while removal at a later stage would occasion a yawning and injurious gap. Much may be done by shortening and trimming branches of undue length and proportion; but very much must be left to the taste and discriminating judgment of the forester. With proper supervision, during the first twenty-five or thirty years, the necessity for the removal of boughs of any considerable size should never arise.

THINNING.

Upon the manner in which thinning is performed much of the ultimate success of a plantation will depend, and as considerable practical knowledge and judgment are required, none but experienced persons should be employed in carrying out this operation. It is hardly necessary to say that the object in view is to afford to each tree its proper amount of room, in the same way as the sanitary authorities require so many cubic feet of air to be supplied to each patient in a hospital. It is to be carefully borne in mind that hardwoods require more room for their healthy development than conifers, while length of stem, produced by a due proportion of shade, is an object of prime importance. It must, therefore, in thinning, be the aim of the forester to arrive at the happy mean, avoiding the misfortune of possessing a plantation composed either of weakly, drawn-up poles, or of a large amount of almost valueless branches and bark-bound stunted stems. The rough rule of allowing two-thirds of stem to one-third of head may be a guide in the case of most of our hardwoods, and as a broad principle, thinning to an extent which will afford to the surface of the ground such a degree of shade as will check any undue growth of underwood should be aimed at.

The most central portion of a plantation, or section of a plantation, will be the most suitable point to commence thinning work, when the conifer nurses will, on account of their more speedy growth, claim the first attention; but while in their case no overcrowding can be tolerated, the danger of suddenly exposing the hardwoods to currents of air or blasts, to which they have hitherto been unaccustomed, must be carefully considered, and it should never be forgotten that to thin in an abrupt or unequal manner is one of the most serious mistakes that it is possible to fall into. The best grown and healthiest trees, and such as are most likely to produce the most valuable timber, should always be left, while distorted, sickly, or stunted specimens should be removed as soon as possible. Straight lines should be carefully avoided, but a healthy tree should not be sacrificed when it contributes to such a formation. In the event of a fine specimen becoming damaged through accident, or appearing in any degree unhealthy, it should be at once removed, and another planted in its place, or should a neighbouring conifer exist, it may be left to fill up the gap. Should two healthy trees be found in close proximity, so that one or both must shortly sustain injury, that one which by its absence will afford the largest amount of space to its ever-increasing neighbour should be removed.

It may finally be noted, as tending to influence thinning work, that the timber of the ash and sweet-chestnut will be found of greater value, for nearly all purposes, when young—say up to the age of about thirty-five years—than at middle or old age.

FELLING.

The late autumn and early winter months, up to January, is the most suitable time for felling hardwoods. At this stage the advantage to be derived from mingling varieties only according to fixed rules will again make itself evident, so that a whole section of a plantation may be expeditiously swept away. On the other hand, if indiscriminate planting has been resorted to, when an apparently suitable time for felling has arrived, all the varieties so mingled will not have attained a proportionately valuable age; thus the necessity will arise, either for removing a certain number of trees prematurely, and at a loss, or for leaving isolated specimens until a future date, under such altered conditions as to shelter, light, and warmth as cannot be favourable to their growth.

The final crop of oak, which should stand at about thirty feet apart, and which it is usual to fell in the early summer, on account of the facilities for drying and saving the bark, will be valuable at the age of a hundred or a hundred and twenty years. The birch, poplar, and alder reach maturity at an age varying from forty-five to sixty years, and the trees should occupy the ground at intervals varying from ten to twelve feet; others, such as the beech, sycamore, horse-chestnut, lime, and elm, at from twenty feet to twenty-five feet apart, will arrive at their full value at the age of eighty or a hundred years.

In cases where heavy and valuable boughs exist, they should be removed close to the trunk before the tree is felled, to prevent their being broken or otherwise damaged by the fall; but some arms should, under certain circumstances, be left intact, so as to insure the fall of the tree in the direction required. The bole should be cut close to the ground, and with as little waste of timber as possible.

BARK-STRIPPING.

When bark-stripping is to take place, some open, airy, and convenient site should be fixed upon for a bark-yard. In selecting such a site, the proximity and direction of forest and other roads in connection with a railway, or other means of conveyance, must be taken into account.

Oak-trees from twenty to thirty years of age supply the most valuable bark, though the occasion to strip much older wood will often arise. As the time for carrying out this work is somewhat limited, all preparations should be made beforehand. The season varies slightly, according to an early or late spring growth, but as the bark will be found to "run" most freely at the time when the buds are bursting, we may as a rule set down the last week of April and the month of May as being the most favourable period. In felling trees of considerable diameter, the bark at the base of the trunk should be first removed, so as to avoid loss, while the boughs may be more easily stripped, before being removed from the fallen tree. The mallet should be used in the work as little as possible, particularly upon the thickest portions, as a too free application of it is apt to cause discoloration, and a consequent loss in value.

For the purpose of drying the bark, racks or tressels, about two feet six inches in height, may be simply formed by driving forked sticks (which are always at hand) into the ground, and laying a cross-bar between them. Against either side of this cross-bar the bark should be laid, the rougher or coarser pieces being placed on the outside, but not so thickly as to prevent a free circulation of air through the whole. This method will be found much superior to that of placing it against the trunks of felled timber. Its inner surface, moreover, should never be exposed to rain or to the direct influence of the sun, and as soon as it is removed, no time should be lost in placing it upon the racks to dry.

As soon as it will snap across rather than bend upon pressure being applied, the drying process is completed, and by this time it will have lost about one-third of its former weight.

The following list of useful hardwood trees may prove of interest to those engaged in afforestation work :—

Acer campestre (Maple).
Acer platanoides (Norway Maple).
Acer pseudo-platanus (Sycamore).
Æsculus hippocastanum (Horse Chestnut).
Alnus glutinosa (Alder).
Berberis vulgaris (Barberry).
Betula alba (Birch).
Carpinus betulus (Hornbeam).
Castanea vesca (Sweet Chestnut).
Cerasus avium (Bird Cherry).
Cerasus padus (Wild Cherry).
Cerasus laurocerasus (Laurel).
Corylus avellana (Hazel).
Daphne laureola (Spurge Laurel).
Fagus sylvatica (Beech).
Fraxinus excelsior (Ash).
Hippophae rhamnoides (Sea-Buckthorn).
Ilex aquifolium (Holly).
Juglans nigra (Black Walnut).
Juglans regia (Walnut).
Ligustrum vulgare (Privet).
Platanus orientalis (Plane).
Populus alba (White Poplar).
Populus canescens (Grey Poplar).
Populus nigra (Black Italian Poplar).
Pyrus aria (Whitebeam).
Pyrus aucuparia (Mountain Ash).
Quercus ilex (Ilex ; Evergreen Oak).
Quercus robur (British Oak).
Salix alba (White Willow).
Sambucus nigra (Elder).
Taxus baccata (Common Yew).
Tilia Europæa (Lime).
Ulmus campestris (Elm).
Ulmus montana (Wych Elm).

V.

THE AFFORESTING OF WASTE LAND IN ABERDEENSHIRE BY MEANS OF THE PLANTING IRON.

By Thomas Milne, *Nurseryman, Aberdeen.*

The attention of possessors of Waste Land cannot be too strongly drawn to the importance of planting. Very large tracts of moor and mountain cannot be improved in any other way, for the land is too poor to pay the expense of making it arable, while, as sheep-pasture, its value is very trifling.

Land situated as high as fifteen hundred feet above sea-level can be planted with profit; it requires but little expenditure of capital, and not only improves the appearance and the climate of an estate, but also pays a very fair land rent.

The method of afforesting may, for convenience, be divided into the following parts:—

I. Preparation of Ground.
II. Plants Used.
III. Method of Planting.
IV. Results obtained.

PREPARATION OF GROUND.

Waste land must be enclosed, in order to protect the plants from sheep; otherwise the young trees run a risk of being destroyed. The ground may be enclosed in several ways; the most common is by means of fences and sunk dikes. These are made by digging a deep ditch, throwing the earth up on one side, and running a single wire along the ridge so formed. This is quite sufficient to exclude sheep, but where deer abound, special fences require to be erected to keep them out.

Should the ground be wet, it is necessary to drain it, and if a spring is the source of the moisture, one deep ditch leading up to it is sufficient to carry off the water. If, however, the ground be all wet, numerous shallow ditches must be dug from thirty to forty feet apart, according to the nature of the ground, with a few main ditches to connect them and carry off the water.

Waste land is generally covered with heather, whins, or broom. If the growth is heather over one foot in height, it must be removed, and this should be done by burning three or four years before planting is commenced, since newly-burned ground is not so suitable. Short heather need not be removed.

Whins are more difficult to get rid of, as burning seems only to encourage their growth. They are usually closely cut; but this is a very expensive process, sometimes costing from £3 to £4 per acre before the ground is properly cleared. The following cheaper method may, however, be adopted where the ground is thickly covered. Roads from a foot to eighteen inches wide, and about four feet apart, are cut through the whins, and the plants are put in along these. For the first few years a man must be sent round annually to cut off any of the whins that may be interfering with the growth of the plants. This method succeeds very well where there is no ground game, for the whins shelter the young plants. When there is game, to which the whins afford cover, the seedlings run a risk of being destroyed, and some other means of clearing should be adopted.

Broom, when it covers the ground thickly, may be treated in the same way as whin.

Where there is very rank grass or ferns, it is necessary to pare off patches of the surface about fifteen inches square and from three to three and a half feet apart, to give the plants which are placed in the centre time to get a fair start before the grass grows high enough to choke them. When this is done, the young trees which are unable to withstand severe frost should not be put in till spring.

PLANTS USED.

By far the most profitable woods to plant on waste land are Scots pine, larch, and spruce. These come to maturity sooner than hard woods, and they succeed well in situations where hard wood will not grow at all.

Until about twenty years ago most of the plants used in the north of Scotland for afforesting waste land were two years' seedlings, but since then two years' seedlings which have been one year transplanted have been used, as they are stronger and better rooted.

The mistake of forcing the plants with manure in the nursery is often made by nurserymen. This gives fine tops but poor roots, and consequently when planted on waste land the seedlings receive a check, while, as a rule, the poorer the soil of the nursery is, the better do the plants succeed when transplanted.

In the north of Scotland the usual number of plants per acre is about three thousand. The reason for planting so thickly is that the young trees shelter each other, and so are better able to resist storms.

The proportion I recommend is two thousand Scots pine and one thousand larch per acre, for, taking waste land all over, it is more suitable for the former than for the latter. Where the ground is of a hard bottom, and very poor, larch plants will not come to maturity, although for the first fifteen or twenty years they take the lead of the Scots pine. If, after that time, they do not seem likely to succeed, they may be cut out, and the pine alone left for the final crop. Larches cut when fifteen years old are of good value, although Scots pines at the same age are worth little or nothing as timber.[1]

At high elevations larch thrive best, the reason being that as the pines do not shed their leaves in winter, their branches are more liable to be broken down by snow.

As spruce does not come to maturity save on very good land, it is seldom much used in the afforesting of mountains and moors.

Young plantations should be thinned as soon as the branches of the trees begin to interfere with each other.

Roads should be made through plantations to afford easy access to all parts of the ground. If they have not been marked off before planting, they may be made at any time, until the trees are ten years old; after that it is dangerous to open up young forests, as the wind admitted by the roads often causes great destruction to trees not accustomed to withstand its full force.

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[1] Most foresters confine the planting of larch to soils and situations suited to its growth, and plant Scots pine only on the shallow ground overlying the rocks of a mountain-side, and on mossy moorland.

METHOD OF PLANTING.

Of the several methods of planting which may be employed, that by the planting-iron only will be described here, as it is most familiar to the writer, and is believed to be the most economical on account of the rapidity with which it allows the work to be done. During the last forty-four years I have had charge of planting about ten thousand acres of waste land, both moor and mountain, chiefly in Aberdeenshire; and of the thirty millions of trees required for that area, about six millions were planted with my own hands.

The *planting-iron* is not generally used south of Aberdeenshire, but in the north it has been known for a long time, certainly for more than seventy years.

The instrument (Fig. 1), is about seventeen inches in length, and as it weighs about three pounds, it can be conveniently used with one hand. The planter holds the "iron" slackly in his hand, and strikes it into the ground with a force sufficient to drive in the blade about three and a half inches. It is then pressed down, and towards the planter; a slight twist given to the right raises the left corner of the sod, and the plant is put in before the tool is withdrawn, care being taken that all the roots are under ground. The "iron" is then removed, and when the sod sinks back to its place, it is struck with the point to break the spring, and the planter as he steps forward puts his heel on the cut sod, and so fixes the seedling. By this method plants can be put in among the crevices of rocks, where it would be impossible to place them in any other way.

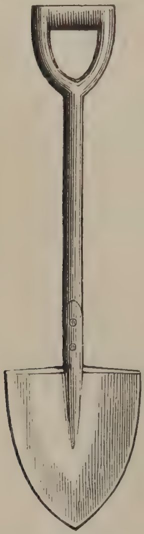

Fig. 1.
The Planting Iron.

From five hundred to eight hundred plants, according to size, are carried in a bag slung over the shoulder, and hanging down at the back, so as to be within easy reach, and yet not impede the man at his work.

Having everything so conveniently arranged, an experienced workman, on good land, can plant from four hundred to five hundred seedlings per hour, or from one to one and a half acres per day.

To make sure that none of the ground is missed—as in places where the heather is rank the plants are not easily seen—the planters are guided by wooden pegs fixed about fifty yards apart. The men should keep about a yard behind each other, and, as each peg is reached, the first man removes it and throws it over to the last, who fixes it in the line of his plants. In this way as many as ten can plant together.

Until twenty years ago the average cost of afforesting, including plants and their carriage to the ground, was from 11s. to 15s. per acre. Since that time, owing to the higher rate of wages and the larger size, and therefore greater price, of the seedlings used, the average cost has been raised to from 20s. to 30s. per acre.

There are great difficulties to contend with in replanting old woodlands. It is safest to replant either in the first year after the wood is cut, or not until nine or ten years have elapsed, and the old roots are decayed. An insect (*Hylobius Abietis*, or Fir Weevil) is harboured by the old roots, and strips the bark off the young trees. It is in old woodland also that ground game does most harm, as the surface, being generally grassy, attracts the game, which often does great damage to the young woods. Rabbits somehow do not seem to touch the plants naturally sown, though they may be of the same size as those artificially planted; probably the nursery-grown plants are more tender and juicier.

The season for planting extends from November 1st to the end of March. If there is a cover on the ground it is well to plant in autumn, but if the ground is bare, either because it had been lately burned or is newly-cut woodland, it is better not to begin the work until March, as the severe frosts of winter destroy many of the plants when there is no protection. The seedlings require very little attention; they are merely carried to the ground, set on their roots, and a little heather spread over them to protect them from frost. After the sap has begun to circulate freely, great care must be taken to keep the roots well covered, as they are very easily destroyed when in that state.

RESULTS OBTAINED.

The plants put in with the "iron" succeed quite as well as those put in with the big spade. In one case which might be mentioned, a forester, who had very strong objections to the use of the iron, acknowledged that the plants put in by it had succeeded far better than those which he had planted with the spade at double the cost. I visited a hill on the estate of Balfour, in Birse, a few months ago, which I planted in 1842, and the forester considered that a good many of the larches there were worth over £1 each; and other plantations have succeeded equally well.

The results may also be seen in the improved climate and appearance of some of the parishes of Aberdeenshire, which, sixty or seventy years ago, were scarcely cultivated, but which are now covered with thriving forests and fine farms.

VI.

THE CULTURE OF TREES ON THE MARGIN OF STREAMS AND LOCHS IN SCOTLAND WITH A VIEW TO THE PRESERVATION OF THE BANKS AND THE CONSERVATION OF FISH.

By Rev. Evan Maclean, *Glen-Urquhart, Inverness.*

The special question of culture of trees on the margin of streams and lochs in Scotland is only a part of a great whole, but yet a very important part, and a matter that appeals in a special manner to the great landowners, who alone are capable of undertaking to carry on a system of forestry of any kind. In the present instance of tree-culture, the question is, how it can be done best and most economically, with the twofold purpose of preserving banks and conserving fish; or, in other words, how, with these purposes in view, and well served, such a system of tree-culture can be adopted with the maximum of indirect advantages.

It may be laid down at the outset, and accepted as a general axiom, that treeless areas are invariably afflicted with drought, while forests are favoured with abundant rainfall. It would be quite superfluous to give instances of the destruction of forests changing the climate of a country, by the gradual drying up of springs and streams, and consequent widespread barrenness. The presence of forest trees must more or less help to moderate the severity of the climate of a locality; it tends to regulate and preserve more uniformly the supply of springs and water-courses. As ground covered by trees retains a large proportion of rain, and as its escape from the soil of such areas is less rapid, streams in the vicinity naturally become less flooded, and their water-supply more regular and continuous, effects which operate alike in preserving the banks and conserving fish.

PLANTING BY RIVERS.

It should be regarded as a preliminary requisite to the planting of river-banks to have nurseries established as near as is convenient to the localities where the plants will be required, so that they may not, when transplanted, be affected by difference of climate, and the treatment of the plants should be such as to qualify them for successfully adapting themselves to the soil and position to which they are to be transferred. Perhaps all young trees should be transplanted from the seed-beds into positions in the nursery approaching, where practicable, those which are to be their future homes. The state of the plants should suit the soil and site. Robust seedlings with well-furnished root-fibres are best adapted for exposed places, while for sheltered positions those moderately furnished with roots will answer. For open, sandy, stiff, or tenacious soils, the plants cannot be too well rooted.

There is no more suitable situation for the forests of a country than along its streams and rivers and loch margins, nor in Scotland a more natural way for its indigenous trees to commence reconquering its barren wastes and bleak moorlands by gradual natural reproduction.

The lands surrounding the Scottish lochs and streams exhibit every kind of aspect, exposure, elevation, climate, and soil, and the planter's art is called out in suiting his seeds or plants to the present and varied circumstances of each case.

Let us first lay before us the task of planting the margin of some stream, representing every variety of site and soil, and suppose the work to begin from below, where the stream flows straight, opening seaward, and is swept for miles by the prevailing wind. We would begin by planting in front some strips of the *Pinus maritima* with three-year-old plants, or rather transplants, interspersed with a mixture of *Sambucus nigra* and *Hippophae rhamnoides* in equal proportions, and on the inland elevated parts, along the bed of the stream, rows of black Italian poplar, the plants being some three feet in height. Some protection from storms is likely to be required in such an open situation, and this might be afforded by dikes, or screens of brushwood. Nearer its source the river passes through an inland glen, where more variety and picturesqueness make themselves manifest.

In a representative valley we meet still with a soil suitable for the poplar along the stream. We mark the deep loam with clayey subsoil as admirably suited to the oak, the deep loam with gravel as best adapted for the elm and the ash, and the calcareous gravel upon chalk as the favourite situation for the beech. In our survey of its winding course, over level and undulated plains, through sheltered vales and deep ravines, we meet with soils upon which almost the whole tribe of deciduous trees might live and thrive. Its sinuous course along the ascending moor and colder uplands, the region of stone, sand, shale, heath, and moss, is the most natural abode for the resinous trees.

It will be understood that every precaution is taken to prevent erosion of banks of streams by such means as the circumstances of the case will suggest. The means to be adopted must be regulated by the nature of the stream and its adjoining banks, as well as by the kind of material conveniently at hand.

The course of a stream is often altered by an accidental obstruction lodged in its bed during a flood, changing the direction of the current, and causing it to undermine the foot of the bank. The important point here is to regulate or prevent such insinuations of the main current, and for this purpose the obstruction may be removed, and the stream allowed to return to its natural course, or its force may be directed elsewhere, by some artificial means, such as roots, stones, or piles. In all cases a careful inspection of the banks should always be made immediately after floods.

In the meantime, let us suppose that the erosion is observed to take place in a sudden turn of the current. Its prevention may be effected by paving the foot of the bank with rough stone sets, sinking the first course well into the bed of the stream, and continuing the stone-work at a gentle inclination for a foot or so above the regular water-level. If sufficient stones are not at hand, it will be necessary to drive one or two rows of piles a short distance from and along the front of the bank, sunk level with the water. The distance may be regulated by the height and length intended for the slope. And as the bend is sudden, it is expedient to give the stream an easier sweep by keeping the piles further into the river at the widest part of the curve, so as to lessen the force of the current on the bank. The piles may be woven beneath with branches, and secured on the landward side by a strong spiked plank having its edge level with their tops and fastened to a further support behind. The intervening space between them and the bank must be filled up with stones, rough gravel, or other materials, so that suckers of willow or birch might be thrown out in suitable places. Building should be resumed by laying the first course of stone sets on a level with the top of the plank. The upper part of the bank might be finished with any inclination required; and roots or cuttings of willow, when the sap is dormant, should be inserted in front; or sods, with roots of thorn, might, where convenient, be utilised in such instances. If this is done, the whole slope will ultimately become one mass of roots, which will effectively bind the stones together, while drooping branches, dipping in the water, will help to throw off the force of the current. This is a passing instance in which it may be said that

> "There is a willow grows aslant a brook,
> That shows his hoar leaves in the glassy stream."

Of course other varieties of plants, such as a crop of alders, by becoming lodged among the débris of the floods, may spring up, and thus increase still further the growing resistance of the bank to the power of the current.

Considerations of site and soil must naturally determine the kinds of plants suitable for different elevations; and the cheapest or best method of preparing the land for their reception must entirely depend upon the nature of the soil itself, and the kind of plant or seed to be used. The taste or choice of the planter, and other elements of practical utility, must also be allowed a free scope.

It is here convenient to point out the most favoured spots on both banks along the whole course of our river for fruit-trees and fruit-bearing bushes. There are thousands of such sheltered and suitable places along the banks of our Scottish streams. The choice of sites must, of course, be ruled by such considerations as good soil, exposure, and aspect. Deep moist valleys, or such places as are always exposed to the effects of frost, should be avoided, though coppice-woods might be laid down in these places. The ground should be well prepared for receiving fruit-trees and bushes by being trenched and manured if possible. For spring planting, the best time for trenching is just before Christmas. Whether the method of planting should be by trenching or pitting, or open or hacked trenches, or even in some instances by the time-honoured styles of slitting or notching, is a matter that must be decided by the nature of each case and the wishes of the planter. But I want to plant the banks of his streams, where suitable, with rows of fruit-bearing trees, and rows and rows of fruit-bearing bushes. It is not necessary to use good ground that could be profitably devoted to any other food crop. It is already known that fruit-bearing trees will thrive in hedgerows, or they may even be formed into a hedge of themselves, by being trained after the dwarfing system. Gooseberry bushes, and other bushes in sheltered places, may be similarly trained by means of strong wire-netting. Let no one say that a cultivation which is so common in other fruit-growing countries in Europe, with no better soil nor climate than our own, will not succeed in Scotland. Let proprietors but give it a fair trial, and they will ere long be rewarded tenfold. They would create a new industry —a thing to be welcomed in these days of agricultural depression,—and thus help to allay the feeling of discontent among tenants, not by lowering rents, but actually while increasing them.

I do not think that places so planted could come under the title of tithable lands, as they could not be properly called fruit-plantations, since they would not interfere either with the value of arable land or that of pasture. Besides, the cost of such trees, when bought in quantities, is no higher than what is paid for forest trees trained for avenue and hedgerow planting. Nor will they require greater care or treatment. Of course rabbits must be made conspicuous by their absence, otherwise the trees must be protected by bark or withered twigs or branches, or covered over with coal-tar or blood. It is unnecessary to add that draining requires to be attended to; but the particular kind to be recommended is a matter entirely dependent upon the nature of the case. It may be remarked that along a steep hill-side, where any running water enters a stream over an open soil that gives way, the course of the current should be inclined or turned off obliquely along the side of the brae, by means of a deep open trench. It may be also noted that where the moderately cheap method of hacked trenches is preferred for planting, it will be an advantage, where the soil is stiff and heavy, to direct the trenches to be made up and down, so as to allow the water to drain off. On dry hillocks, on the other hand, such drains should be made horizontally, so as to catch all the water.

The cost of planting must, of course, depend upon the amount of preparation required by the land, the size of the seedlings, and the mode of planting and management. The subsequent treatment of keeping up fences, and keeping down rabbits and weeds, applying so specially to fruit-trees, would not need to be uniform in the case of such planting as this, nor apply at all to forest streams or places not frequented by sheep and cattle. Many deep ravines or gullies, if not self-protected, could be easily protected with very little cost. The alder and willow planted near the edges of the stream to prevent erosion, and in other wet places along the adjacent banks, would need no protection. Osier beds should be laid down in suitable places, the different kinds of willow to be chosen according to the different purposes in view, such as material for crate, etc. In this way the fruit-growing industry, while affording healthy employment for women and girls, would at the same time stimulate the industries of osier-growing and basket-making.

In sandy banks with some gravel, the hazel and the chestnut might be successfully reared from their seeds or nuts; but in the lower plains and more sheltered situations it would be better to use plants of two or three feet or more in height. The oak, ash, elm, or chestnut, might be placed here in their respective soils. These, like other deciduous trees, are best planted in autumn, and might be protected singly where necessary. As the planter begins to ascend the rising braes, and comes upon the natural habitat of the common hazel, Scots thorn, and hawthorn, he may feel sure that most forest plants will flourish there. Such trees as the birch, hazel, mountain ash, and beech, may be recommended specially. As he ascends the stream he comes to regions better suited to the nature of the resinous trees, which should be planted in spring, especially the larch. Here notching, as it is the most expeditious, and so the best method of planting, may be resorted to. Along the moorland heights a mixture of Scots pine, larch, and birch and mountain ash will suit in the more sheltered parts, but Scots pine and birch in the more exposed and higher situations. The most sheltered spots along the stream might be planted to begin with, and especially the neighbourhood of deep natural pools. When these trees grow so as to afford shelter, the planting may be extended.

It may be remarked, in a general way, that, where circumstances are favourable, it would be better for the planter to sow the seeds of trees intended for growth as shelter, whether by stream or along the shores of lochs. It would be also of great advantage to have small temporary nurseries established, as required, where seedlings of the necessary varieties could be transplanted, and be thus in a great measure acclimatised to suit their ultimate localities.

PLANTING BY LOCHS.

In regard to planting on shores of lochs with the objects in view, it will be admitted that such work must be greatly ruled by the nature of the site, soil, and exposure in each case. Let us here also take representatives of Scottish lochs; one high mountain loch will typify the hundreds of the same kind, and one on the lower plains will represent the case of those situated near the sea-level.

I shall first refer to the high mountain loch, where it is necessary, in the first place, to observe carefully the direction of the prevailing wind. This may be sometimes seen by the effect of the action of the storms and waves in crumbling and tumbling down the deep moss bank on the exposed side. I know more than one loch in which all the fish have died owing to the water getting thus periodically thickened and dirtied. Indeed the effect of any open moss bank in the face of the wind is anything but conducive to the conservation of fish. Such a peaty bank is the only kind of soil that does give way on the shores of mountain lochs, and this waste could clearly, in course of time, be prevented by planting. The moss, after being well drained, might be planted with hardy Scots pines, two-year seedlings one year transplanted, some larch, one-year seedlings one year transplanted, and birch plants from fifteen to twenty inches in height. These may be taken as the best pioneers, although other deciduous varieties will also grow when the moss gets solidified. Both ends of the loch should be planted with broad strips as wind-breaks, as the ends of Scottish mountain lochs generally indicate the directions of the prevailing winds. When newly planted these stripes should be protected from the force of the wind at their more exposed parts by raised earth-heaps or turf walls. Where it is difficult to rear plantations on the exposed sites owing to the violence of wind, the situation may be approached by planting the more sheltered places alongside first. Belts of plantation around our hill lochs would of necessity tend to modify the temperature of the atmosphere, and they would become nurseries for myriads of flies, which in merry companies would be carried by every wayward wind to and fro over the water's surface, to the inexpressible delight of the finny tribe below.

The other representative loch is situated in a lower district. The only waste observable on its shore is at its inlet end, where the sand or the débris received for years has accumulated, long before its outlet channel had become so deep or itself such a diminishing picture of what it was in other days. There is required here before planting some shelter from the fierceness of the east wind. A good screen of brushwood, composed of cut branches of spruce fir, or any other tree loppings, should serve to give the young trees a favourable start. This may be raised to resemble a hedge, by having the spruce or other branches fixed like garden pea-stakes to two lengths of paling rail, securely fastened to stobs of some six feet in length above the ground. The wind will not rebound over this as it does over a dry-stone dike or turf wall. Under the shelter or inside this dead hedge may be planted first, and in about equal parts, the common elder and the sea buckthorn, and the plane-tree or sycamore. The tree mallow, the evergreen oak, and varieties of the willow and of the conifers, may be interspersed amongst these. To some of the above-mentioned trees for planting the sides and shore may be added the birch, ash, elm, oak, the alder in wet places, and the poplar, notably the *Populus tremula*, will thrive here and there. Of course there are so many of the smaller shrubs and bushes that are very well adapted for such use as this, as well as to serve as nurses for the larger trees when first planted, that I cannot do more than mention the names of some of them, as the common Scots rose, hawthorn, holly, snowberry, *laurustinus*, *ribes*, lilac (*syringa*), bird-cherry, *Spirea adiantifolia*, the *Mahonia*, and the common *Arbor vitae.*

In these remarks I take for granted that the preparation of the soil, even the trenching of it where necessary, is to be attended to as the nature of the case demands.

The important point to be observed in cases where planting cannot be commenced at once, and these cases will be found most common, is to select suitable sites for the initiatory nurseries and plantations, and to start these.

Success, in the highest sense, in tree-culture, must of necessity be attained only by the work of years. But in a short time the good effects of lining our lochs and streams with young trees would tell in moderating the climate, in purifying the water and in regulating its supply. Trees also contribute to the fertility of land, and I have noticed that wherever land is fertile fish abound in the neighbouring waters.

Along with the effect of tree-planting in conserving the fish supply, it is necessary, in many cases, to have recourse to the artificial increase of the number of fish, an enterprise which, although yet only in its infancy, seems to have boundless possibilities before it.

Both tree-culture and fish-culture are specially reserved by their nature for landowners; they are both new and yet but partially explored fields, in which they alone are competent to make a name, and by becoming benefactors to themselves become benefactors to their country. And theirs is a charming task, in which a great duty becomes a high privilege, and in which pleasure and health and beauty mingle in harmony with utility.

VII.

ECONOMICAL PINE PLANTING,

WITH REMARKS ON PINE NURSERIES, AND ON INSECTS AND FUNGI DESTRUCTIVE TO PINES.

By David Cannon, *Les Vaux, Salbris, Loir et Cher, France.*

GENERIC CHARACTER OF PINES.

All Pines at present known are evergreen trees. They constitute a most important and widespread genus of the great family of Coniferæ.

Their branches form, at regular intervals, verticils or whorls, bearing linear needle-like leaves, united in groups, generally of two, three, or five, by a short sheath enclosing their base. The leaves usually remain on the stem for two or three years before falling.

The flowers of the pine are monœcious, *i.e.* male and female flowers are found in separate catkins, but on the same tree; the former in spikes, at the base of the shoots of the season, the latter solitary or in clusters, generally at the ends of the boughs. The cone, which takes a year to ripen, is composed of woody scales, thickening towards the summit. Each scale bears, on the inner side of its base, two seeds, generally furnished with membranous wings, which aid in their dissemination.

In our climate pines have (with a few exceptions, such as that of *Pinus pinaster*, in Central and Southern France) only one strong upward flow of sap during the year. This takes place in spring, and their growth in height can be measured annually by the distance which separates one whorl from another. No adventitious lateral branches are developed along the leading shoot, as is the case with firs, larches, cedars, cypresses, and most other Coniferæ.

The special botanical characters of the pine genus are thus strongly marked by two leading peculiarities, first, their branches are in whorls, with clear intervals of bare stem between ; and, second, their leaves are united in sheaths. It seems certain that the new annual shoots continue for a second year at least, if not for two, to contribute to the growth of the tree, by stretching out in length as well as gaining in thickness. This is remarked by White of Selborne, who relates that in the case of a conifer observed by him the lower part of the tree, which was hidden by some buildings, gained height not only by sending up new annual shoots, but by pushing up the whorls that already existed above the line of roof which had formerly concealed them. The same phenomenon is shown by the fact that even in favourable years the top shoots of young pines, which are known to be gaining vigour every year, still seem, at the end of their growing season, to be inferior in length to those of former years. When observing and calculating the average annual growth of pine woods, it may be useful to take this circumstance into account.

The pine genus comprehends a great number of species, but comparatively few are suitable for forest cultivation on a large scale.

With regard to soil, the requirements of the genus are very moderate, as from comparative analyses of their wood, they seem to need the smallest quantity of mineral constituents of all trees. By means of their evergreen leaves they have the faculty of absorbing, throughout all seasons, the carbonic acid in the atmosphere, of which they assimilate the carbon, and return to the air the pure oxygen. They contribute powerfully to drain the soil by giving off gradually to the air, through their leaves, in the form of vapour, the moisture drawn from the subsoil by their roots. They thus keep up a constant circulation of moisture between the earth and the atmosphere. This, moreover, explains why resinous woods are drier than broad-leaved ones in winter, during which season the latter, deprived of their leaves, are unable to continue a similar circulatory function.

It is also supposed that the needle-like form of pine leaves attracts the electricity of a stormy atmosphere, and that this enables them to absorb, to a certain extent, the nitrogen of the air, as well as that contained in the nitrates and ammoniacal salts dissolved in rain-water.

The wood of pines is perhaps the most useful that man possesses. It furnishes materials for house and ship building, flooring, and furniture, railway sleepers, telegraph posts, street pavements, and fencing of all sorts. On the Continent it is largely used in the baking of bread. It also yields abundant charcoal; much of its produce, such as resin, turpentine, and tar, is valuable in manufactures; and some excellent medicinal preparations are derived from it.

Some species of pines may be planted with confidence in any soil which is not good enough for deciduous trees, as they require less moisture, less depth, and less fertility than the latter, and some of their species sustain triumphantly the struggle for life with the weeds, grass, and heather that take possession of waste ground, but which are in a few years killed by the rising pine wood. Like all other Coniferæ, they are also useful as nurses to broad-leaved trees, especially oaks, which, when planted alone, are very slow in covering the ground.

They are, moreover, valuable as a means of replenishing worn-out forests of broad-leaved trees with light cover, under which weeds and shrubs often take possession of the soil. Such regeneration is carried out on a large scale in the forests of France and Germany, and generally with perfect success.

PREPARATORY WORK AND GENERAL OBSERVATIONS.

In the choice of plantation land a general plan should be followed, with a view to obtain the conditions most favourable for the development and management of the future wood. Small isolated patches, surrounded by pasture or cultivated land, should be avoided by the forester, however attractive they may be to the artist and the sportsman. In unfenced countries they are troublesome to the agriculturist, and always more or less ravaged by cattle; and the cost of fencing, where necessary, is, in such cases, so great as to be almost prohibitive. Moreover, their growth is liable to suffer from want of shelter, while their management and the sale of their produce are hampered on account of their isolation. The forester, therefore, should endeavour to mass his plantations together, and in making new ones, to choose ground as far as possible continuous with that already planted.

Before commencing the work of afforesting it is absolutely necessary to insure that the land shall be free from all stagnant water, and it is at least expedient that the roads and rides necessary for visiting and working the plantations be laid out from the beginning. The work of draining, where necessary, and that of road lining, should be as much as possible carried out together, as the ditches keep the roads practicable, and the roads facilitate the work of inspecting the ditches.

When the new plantations are continuous with the old it is easy to continue through the former the set of roads and walks existing in the latter ; or if such a set has not been constructed, to form a complete one throughout both.

These roads should be, as far as possible, within view of the proprietor's residence, and in direct communication with it. A number of long forest avenues branching out, like the spokes of a wheel, from the site of the manor-house, or from a point within view of it, has a very fine effect. Besides, it is of the greatest importance, with regard either to the management of woods or to the enjoyment of their beauty, to be able to go to them rapidly, and without discomfort or delay in any weather. The roads or rides should therefore not be more than 100 yards apart each way ; their minimum width should be five yards, and that of the principal ones six or seven yards. The latter width, besides being convenient and agreeable to the eye, leaves space for a ditch to run along the side of the road. Moreover, the branches of the pine soon spread, and the forester is astonished, at the end of a few years, to find openings that he had at first considered too wide nearly closed up by their growth.

Considerable saving is effected by laying out roads in advance, and leaving them unplanted. Two roads of our minimum width of five yards, laid out at right angles on each section of wood 100 yards square, take up exactly one-tenth of the whole superficies ; and in most cases it would be bad economy to plant these in order to realise the trifling produce of the first thinning, on which occasion it becomes positively necessary to open out the passages.

The spaces for the roads having been laid out, it is advisable to mark them by planting along each side a line of broad-leaved trees. In poor and shallow soils, not devoid of moisture, the birch will serve remarkably well for this purpose, and it will relieve, by its bright hues and elegant foliage, the dark monotony of the pines, while its tough and supple branches are useful for tying the pine fagots. Where the soil is excessively acid, larch may be substituted, its growth being equally rapid, and its foliage contrasting as happily with that of the mass of pines behind it. In better ground, the plane, the sycamore, or the red American oaks, will form superb borders, and add immensely to the charms of the woods, while they are at the same time valuable as timber trees. Such species, however, will often require to be protected against ground game, and care must be taken not to allow the pines to invade and smother them. The Scots pine is especially inclined thus to treat all plants that dispute the ground with it; it " bears, like the Turk, no brother near the throne."

The drainage necessary varies according to the position and nature of the soil and subsoil. In sandy high-lying ground it sometimes may be dispensed with altogether, although the low-lying lands in most cases require more or less, according to circumstances. On the sandy, but in some cases damp or marshy, soil of Central France, it has been found that drainage of the surface soil suffices to allow successful planting of the hardiest pines, which, when they are well settled and grow vigorously, defy the humidity of the subsoil, and even, in most cases, suffice to drain it themselves by the action of their roots and leaves before mentioned. It may be observed, as an instance of this natural drainage, that an artificial pond, made by the author about twelve years ago, which was at first fed to overflowing by drainage water, was ultimately dried up as the growth of an adjoining plantation of mixed coniferæ continued, owing to the greater root-absorption of the water which formerly fed it. Many other instances of marshy ground that has been rendered quite dry by plantations of Scots pine are on record.

Although drainage of the subsoil, as recommended by Dr. Brown,[1] is certainly preferable, the immense cost of such work—to which there must be added, as to all planting expenses, compound interest until the first paying returns from the plantation—tends to be prohibitive of planting; and even where practicable, it must be considered whether the surplus of production would compensate for the extra expense. As surface drainage, however, is in most cases sufficient for the hardy pines, intending planters should content themselves with this in the first instance.

This surface drainage is sufficiently effected by making, along each roadway, a ditch three feet four inches wide at the top, fifteen inches at the bottom, and twenty inches deep, into which the surface-water standing on the square of ground served by the road may be directed by means of cuts varying from a foot to eighteen inches in depth. Such ditches in France cost about three farthings a yard, and the secondary cuts from a farthing to a halfpenny. The earth taken from this ditch is spread over the road, and so prepares it for carting.

When the slope is transverse to the direction of the road, the single ditch just mentioned should run along the upper side of the latter so as to serve as a check-drain, and prevent injury to it.

The most useful secondary drains are those that cross the slope of the land, as they intercept and carry off the water that filters through the soil. If the land planted was formerly cultivated, as a matter of course the ditches that formerly served to drain it should be cleaned and rendered serviceable.

In heath land, mere cuts, as narrow as possible, and twenty inches deep, will be preferable to ditches. These are less expensive, as less earth has to be removed, and the roots of the heath maintain the sides of the drains, while the shade afforded by the meeting of these plants over their mouths prevents the growth of weeds and grass, which tend to choke up wide ditches, at the bottom.

In newly-planted ground the passage of carts is not usually necessary, there being no produce to export, but where such traffic has to be carried on, the best conduits for the drains are insured by laying down, where they cross the roads, round tiles of earthenware or cement. If the expense of these is objected to, the open ditch may simply be filled at the crossing by a pile of pine or willow fagots, if possible devoid of leaves. These should not be covered with earth, as this falls into the interstices, chokes the ditch, and rots the branchwood. Such fagots will keep sound for years, whereas those of oak or birch rot in a short time.

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[1] *The Forester*, p. 156.

In all enclosed countries fencing is necessary, and is an important item in the outlay of planting, for a fence must be strong enough at all points to resist the rough assaults of cattle. It may be noted, however, that, of late years, the cost of wire-fencing has very much diminished, and that beech or hornbeam is often useful for forest purposes in this connection.

All are agreed that cattle should be strictly excluded from plantations of pines till the trees are at least thirty years of age, as the younger wood is liable to have its bark damaged by the animals rubbing their greasy coats against it. Forests into which cattle are admitted must be continuous on the ground, for if there are any waste spaces, such animals prevent the natural restocking, and ditches for drainage must be unnecessary, as in such circumstances they soon become choked up. Under all other circumstances no cattle should be allowed to enter plantations.

In some poor districts a very bad custom prevails, of raking the dead leaves off the ground, to furnish litter for the farm-yard, and beds for the cotters' cows. This practice impoverishes the soil by exporting its produce, and leaving nothing to replace it; and as land put under pines is generally of the poorest kind, it is evident that it cannot long withstand such exhausting treatment.

Leaves are the most important agents in increasing the fertility of woodlands. Not only, according to the interesting experiments of Dr. Weber,[1] Professor at the Forestry School of Aschaffenburg, in Bavaria, do the leaves contain the greater part of the mineral constituents of the tree, but they are also full of organic matter, the elements of which they have absorbed from the atmosphere. They are, moreover, of the utmost service to the soil, in preserving it from drought on the one hand, and rapid denudation on the other.

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[1] *Allgemeine Forst u. Jagd Zeitung, Januar* 1881, translated by L. Tessier in *Revue des Eaux et Forêts*, Paris, vol. xxi. p. 457, and summarised by the author in May 1884, p. 52 *et seq.*

The extraordinary effect, first, of the existence of a leafy canopy over forest land, and, secondly, of the covering afforded to the soil, in reducing direct evaporation from the surface of the ground, has been the subject of a series of interesting experiments in the United States. Mr. Franklin Hough,[1] reporting to the Commissary of Agriculture the results of these observations, concludes that if evaporation, on a given space of bare land, be estimated at 2194, under forest, without litter, it would be reduced to 847, and under forest, with litter intact on the ground, it would be further reduced to 333. In this manner a leaf canopy diminished direct evaporation from the ground by 62 per cent.; and the litter formed by fallen leaves diminished again this already reduced proportion by 61 per cent., bringing down the amount of direct evaporation from the soil to less than a sixth of what it was on bare land! It must not be supposed from this that the diminution estimated applies to *all* evaporation from forest land, as in that case the soil would soon be loaded with an excess of moisture. Direct evaporation from the ground is indeed reduced to a minimum, but the process is still carried on by the trees themselves through their leaves.

The entire cost of planting is composed of several items, the first and most important of which is the loss of interest on the market value of the land afforested, *i.e.* on the price its proprietor has paid for it, or on that for which, if so disposed, he could sell it. Taking into account all delays and disappointments encountered during the work, and the difficulty, in the remote and poor districts where pines are mostly grown, of disposing to any advantage of the first small thinnings, it is improbable that, on the average, any proceeds worth mentioning can be got before twenty years after the time when the land was reserved for afforesting. Compound interest on that period amounts, at 3 per cent. per annum, to 80·5 per cent., and at 4 per cent.

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[1] *Forestry* for September 1883; Article on "The Destruction of American Forests."

per annum to 119 per cent., on the market value of the land.

To these figures must be added the yearly taxes on the land, and the expenses of keeping up the plantations until their first remunerative yield, with compound interest from the successive dates at which this expenditure is incurred.

These items form the heaviest part of the cost, and as they are invariable, it must be borne in mind that they are the same for a bad plantation as for a good one. And such is the case with fencing, where that is required. The mere work of planting hardy pines can of itself be carried out at a comparatively very small cost. From these considerations we may draw two important lessons :—

First, That it is highly imprudent to buy land or to sacrifice rent on what one already possesses, with the purpose of planting and keeping it, without being certain of being able to sustain such a large loss of income without inconvenience.

Second, That it is the falsest economy to buy defective plants, to employ defective methods of planting, or to put down species of trees not perfectly suited to the soil, on the pretext of cheapness. The heaviest charges on planting, as in agriculture, being invariable, the only way of making our cultivation pay is to obtain the maximum of crop, which can only be got on land regularly covered with vigorous trees, of the sorts best adapted to the nature of the soil. In afforestation work therefore, though strict economy should be exercised, and all useless expenditure carefully avoided, nothing should be spared that is really and practically required for the success of the enterprise.

The different modes of planting and culture will be treated under the head of each species of pine described, and more particularly under that of the Scots pine, which is the hardiest and most generally useful of all the species.

THE SCOTS PINE (*Pinus sylvestris*, Linn.).

This tree is sometimes, on the Continent, called the wild pine —French, *sauvage ;* Italian, *salvaggio ;* Old English, *salvage*— words which, however, come from the same root as *sylvestris,* and mean originally "of the woods." Its branches, which are numerous, in whorls, and generally horizontal, bear leaves about three inches long, and more or less glaucous according to the variety of the tree. This colouring, with the reddish tinge of the bark, gives it a more cheerful general aspect than that of many other species. Its cones, solitary or in small groups, are about two inches long, broad at the base, and pointed at the summit; their scales end in a point, their seeds, which are small and grey, or sometimes brownish, are furnished with membranous wings which fall off easily, and are so thin as to be almost transparent. This enables the seed to be scattered to a considerable distance.

The names Riga, Russian or Red pine, Haguenau, and Geneva pine, are generally considered to designate only varieties of this species. They are, indeed, perpetual and very distinct varieties, so much so that some botanists are inclined to class them as species. It is possible, however, that they may be the effects produced by the soils, climates, and exposures in which they are grown, acting through many ages on the original type. In this connection it is to be noted that the further north *Pinus sylvestris* is grown, the finer and straighter it becomes. When grown in the south, the excessive flow of sap excited by a larger supply of heat and moisture may be the means of producing an irregular growth; nevertheless its extremely robust constitution enables it to thrive in any climate, from the north of Russia and Scandinavia to the shores of the Mediterranean, and to grow in almost any soil, however barren and exposed to the most unfavourable conditions.

This tree must therefore be regarded as the useful species of pine *par excellence.* It not only grows in but enriches poor soil, clearing it rapidly while young, by means of its thick cover and strong roots, of weeds, grass, and heather, and depositing that thick layer of leaves which is so valuable to the land both chemically and physically. The Scots pine, it is calculated, deposits more humus than any tree, except the beech and the hornbeam, in climates where the latter obtains first-class size; while in hardiness and general utility it is infinitely preferable to either of the latter.

Planting.—All varieties of the *Pinus sylvestris* are easily propagated both by sowing *in situ* and by planting.

Although the former method is not often used in the United Kingdom, it is practised in Central France, and might possibly in some cases be employed in the colonies. It is to be noted, however, that planting is generally the preferable method, provided the seedlings can be defended from the attacks of the rabbit. After the first few years such trees will always be more vigorous, and furnish a greater quantity of more valuable wood than sown ones, because each will have had from the beginning the inestimable advantage of a full and regular allowance of space to stand in and of light to grow by. They are thus enabled to develop strong vigorous roots, which take possession of the soil, and keep them firm under gales and snowdrifts, as well as an abundance of foliage leaves, which are the great organs of respiration and nutrition. Careful planting, too, covers the ground regularly, whereas the result of sowing is often irregular, from difference in the chemical and physical character of the land sowed, excessive production occurring in one place and insufficient in another. We shall now consider (1) Planting; (2) Sowing, (*a*) *in situ*, and (β) in nurseries.

The soil to be planted with Scots pine may be in each or all of the following conditions:—

1*st*, Stubble, after a farm crop.

2*d*, Turf, or partially covered with shrubby weeds, such as heather and furze.

3*d*, Waste ground, covered with old strong-rooted heath.

4*th*, Worn-out woodland.

In any of these cases the proximity of rabbits is highly dangerous; therefore, before planting begins, all cover harbouring these animals must be cleared within some hundreds of yards of the ground to be planted. If the cover be wood, it can be cut or thinned out; if it be heath and furze, they can be burned, great care being taken to circumscribe the fire by means of ditches, or by paring the soil all round to the distance of some five yards. Where rabbits are abundant, and this precaution insufficient to keep them away, it is better, when practicable, to sow *in situ* than to plant. The young pines thus come up gradually, and are generally sheltered by grass or weeds, which serve as a mask for them. Since, moreover, the number of plants obtained is generally excessive, no great harm results though some of them be destroyed.

Planting on stubble land may be effected with seedlings of one, two, or three years. For operating on a large scale, any plants older than three years should be rejected as being troublesome, expensive, and uncertain to succeed. The younger the plant is, provided it be vigorous, the better, as such seedlings can be lifted and transplanted with all their roots, whereas, in pulling up the large ones, not only are their roots necessarily cut short, but they are often injured by having their epidermis peeled off, from the violence the workmen are forced to exercise.

Seedlings of one year, however tender in appearance, succeed remarkably well, provided they have been raised in the planter's nurseries, and are stout and vigorous, and furnished with good roots, as will be the case if sown thinly on well-prepared ground. If they do not fulfil these conditions, they should be transplanted in the nursery, and left there till the second year.

The best two-year-old plants are undoubtedly those so transplanted, as they have formed numerous fibrous roots, and possess a short thick stem, terminated by a stout bud. Similar seedlings, that have not been transplanted, may also succeed very well, provided they be short and stout, and have had plenty of room in the nursery. It is however to be understood that such general rules must be modified according to the climate and other conditions in which afforestation work is being carried on.

In stubble land, seedlings either one or two years of age can be planted in a simple slit made with a well-worn sharp spade. It is advisable to insert the tool somewhat obliquely, so as to raise the earth a little. The latter, after the insertion of the plant, falls back, and covers its roots. Nor has the seedling anything to fear from the sloping position in which it is placed, inasmuch as it straightens itself completely when growth takes place. It is of great importance to see that the slit is well closed *to its whole depth* by firm tramping; for it often happens that workmen only give a negligent side pressure, which merely shuts the top of the slit, and leaves a vacant space further down in which the roots of the plant are.

When the land is covered with stout grass and other rubbish, it is expedient to make holes for the plants. The following system of planting has proved excellent in the above circumstances:—

The workman, with a stout sharp spade, slightly curved like a gouge, and about seven inches wide at its top, turns up—generally, in light soil, with the second stroke—a sod of the same diameter, and about six inches deep. This he turns upside down and replaces in the hole from which he has just removed it; he then tramps it down, so that there may be no empty space between it and the bottom of the hole; and finally, in the loosened soil brought up to the top, he makes a slit well opened out with the spade; the woman following inserts the plant, and closes the slit by treading down the soil.

It is desirable that the seedlings put out should be easily seen, so that the planter may be able at once to examine and control the work done. This control is exercised by simply giving a slight pull to the plant; if it resists, it is well set; if it comes up, the work is faulty, and the lines should be gone over again and carefully trodden down.

In light sandy soils where rabbits abound, and where the grass is short and stunted, and does not overtop the plant, a spade fully half-round like a gouge is employed in planting. This the workman, holding it perpendicularly at arm's length, with the concave side towards him, strikes into the soil, forming a semicircular slit; then turning the tool, he inserts it again from the near side, and leaning on it, easily raises up a cylindrical sod, which he retains on the end of his spade, while the woman following places the plant carefully in the hole so made, in such a way as to lean its collar against the side furthest from the workman, who then replaces the sod, treads it down over the roots of the plant, avoiding as much as possible the appearance of having disturbed the soil, and the operation, which may be very rapidly carried on, is terminated. If the soil is compact, or the plant of a delicate species, it is advisable, instead of putting back the sod as it was, to cut off its lower part, and crumble its earth round the roots, then to cover the hole with the turf of the top. This is an excellent method when well carried out, as the earth tends by its own weight to settle well over the roots of the seedling.

The above methods of planting are chiefly applicable to flat land, which is not very stony, but easily worked. For land of a more difficult nature, the following recommendations are given by Dr. Brown :[1]—

In planting bare rocky parts with the two-year seedlings of larch and Scots pine, and also of the birch, the work is effected "by means of the planting mattock. The handle of this implement is generally made about forty inches long, and of a piece of good ash-wood; the cutting end is about four and a half inches long, and pretty sharp; and the length of the one side, from the face to the eye, is about twelve inches. The other side, instead of being broad and sharp, is made to taper to a point like the common pick. In using this implement for the purpose of planting, . . . the operator takes it into his hand in the same manner as a common pick, and first pares off a thin part of the turf with the broad end exactly on the spot where he intends to plant a tree. Having done this over a space of about six inches square, he next, with the pick end, loosens the soil in the spot pared to the depth of about eight inches, bringing up at the same time to the surface any considerable-sized stone or stones that might interfere with the planting of the tree. In this manner any number of men may be employed, always observing to keep to the specified distance as nearly as circumstances will allow. In general, every two men employed with the planting mattock are followed by one person having the trees in an apron, which he plants in the spots prepared. In planting with small seedlings, he uses an implement called the planting hoe. The iron part of the implement is generally about nine inches long; the mouth or sharp end is made about four inches broad, and is not kept so sharp as the mouth of the mattock, it having to be used in the earth. The handle is about fifteen inches long. . . . In using the planting hoe, he keeps it in his right hand, and digs it into each spot; and by pulling it, when in, a little towards himself, he makes a sufficient opening at the back of it to hold the roots of the young tree, which he puts in with his left hand, inserting the roots very carefully. As soon as the roots are properly put in, he withdraws the instrument, taking care at the same time not to disturb the plant in its position. When the implement is out, he gives the earth, on the side of the hole next to him, a push with its mouth, in order to hurl the loose earth into the hole of the newly-inserted plant, and finishes by tramping and making the earth firm in its place. In this manner three men will plant 2000 plants a day."

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[1] *The Forester*, par. 1603, page 478, 4th edition, 1871.

In very bare or rocky places it is not always possible to get as much earth in a certain spot as will properly cover the roots of the small seedlings. When this is the case, it is preferable to sow the seed in the ground at once. This plan has been adopted in some parts of the West Highlands of Scotland, and has been attended with good success.

In rough land, where it was impossible to use agricultural implements, the following method of sowing *in situ* has been adopted:—A man with a mattock clears and loosens successive little patches of soil from four to five feet apart, and measuring one square foot at the utmost. A woman or child following sows about eight or ten seeds on each patch—for in rough forest sowing, subject to the attacks of many enemies, only a small proportion of the seed develops into plants—and covers them over very lightly. The best season for this work is spring, for if sown in autumn the plants come up just before winter, and are exposed to many enemies during that season. Rabbits are especially destructive, being attracted by the tender succulent seedlings.

If three-year-old plants are used, previous transplantation in nursery lines is absolutely necessary. Seedlings intended to be used at this age should not be transplanted as yearlings, but left in their nursery beds until their second season. If transplanted then they will make, during the year before they are put out, short fibrous roots, and transplant finally with a fair chance of success. If, on the other hand, they are transplanted as yearlings, and left two years in the lines, their roots run long during the second year, and lose the fibrous growth first excited by the change, so that they become liable to injury, and the final putting out of such plants is a perilous operation.

In general, the use of plants of three years of age, when it is certain that younger ones would languish under the cover of high grass, can alone be recommended; although, when the latter can make a start, their growth will very soon outstrip that of the larger seedlings. Nor do the older plants resist the attacks of rabbits, which sometimes cut through the woody stems of young pines two and a half feet high.

Seedlings of three years should be planted in holes as large as possible, inasmuch as the larger size of their roots does not allow of their being inserted into slits like the younger plants.

In high grass it may sometimes be necessary that each pair of planters be preceded by a man with a mattock, who clears a space varying from fifteen to eighteen inches in diameter, in which the hole will be made.

In principle it cannot be doubted that the best season for planting is towards the end of autumn. The seedling put out at this period has the whole winter before it to settle its roots in the soil, and even during a mild winter to grow a few fibrous rootlets, which help it to make a vigorous start at the beginning of the growing season, and to resist summer droughts, which are often fatal. When the extent of land to be planted is large, it is necessary to begin early, so as to work through all the open season, especially as delays, either from unfavourable weather, or from difficulty in procuring labour, are always to be foreseen. Moreover, the planter who buys his seedlings from nurserymen is certain of their freshness when he gets them in October.

Unfortunately, in many cases, the dangers of autumn planting are numerous. Among these may be noted—(1) the ravages of rabbits; (2) the danger that the roots will rot from the presence of an excess of moisture; and (3)—and this is the most important consideration—the soil, when very loose, is liable to settle down under the weight of snow, in which case it literally falls away from the plants.

On the other hand, if heavy, it may split up and open out under the action of severe frost, and so throw out the roots, which will, as in the preceding case, be left bare. Hence, in loose soil covered with grass, autumn planting, as a general rule, cannot be recommended. The best season for such work is about the month of February, when the hard frosts and heavy snows are generally over, and when the seedling has yet some time to settle in the ground before the arrival of the period for growth. If necessary, planting can be carried on until the beginning of April. It is not safe to prolong it further, though seedlings *can* take well until the flow of sap is at its full in the beginning of June.

DISTANCE TO BE LEFT BETWEEN SEEDLINGS IN PLANTING.

Planting should be more or less close according to the necessity of sheltering young trees as they grow up, and according to the means of obtaining sale for the first thinnings. Except on very high mountainous sites, the Scots pine does not require close planting for the sake of shelter.

In Belgium it is usual to set this pine at intervals of about three feet, for the purpose of obtaining at an early period a quantity of hop-poles, which pay well; but as this method requires about 4400 plants per acre, it is only to be recommended in cases where small thinnings find a ready and remunerative sale.

The minimum of distance allowed by practical foresters is three and a half feet for very elevated and exposed situations; but the Scots pine, from its great hardihood and propensity to cover the ground rapidly with strong-growing branches, can very seldom indeed require to be planted closer than four feet. The number per acre required at this distance is only 2500, roads being excluded. This is little more than half of those necessary at three feet, the number used varying inversely as the square of the distance, so that the increase caused by a diminution of a few inches only is enormous.

The distance of four feet should be used only on exposed soils, or where we have reason to fear a considerable number of failures. Such failures may arise from the unsatisfactory nature of the soil, or of the season, or of the plant, or from the presence of vermin or insects. This distance may also be used in localities where small wood is in brisk demand, if such sales be found to compensate for the expense of planting.

In plains and valleys, and all fairly sheltered sites, we have for many years planted at five feet apart in all directions. This system has several important advantages :—

1*st*, A vast saving of time, expense, and labour, is effected ; the number of plants required to the acre being only about 1600 (roads being excluded).

2*d*, A larger extent of ground may be planted in a given time and with the same means.

3*d*, It is possible in isolated districts, where demand is not brisk, to delay the first thinnings until they have size enough to be saleable without exercising any prejudicial effect on the plantations.

It is to be borne in mind, however, that at this distance very few failures can be sustained with impunity, especially if the variety of pine employed is at all inclined to grow bushy where it finds a wide space in which it may spread. If exceptional losses are to be feared, from a dry spring, rabbits, or insects, or any other cause, it is safer to plant at intervals of four feet.

SEASON FOR PLANTING ON GRASS LAND.

In contrast with planting on stubble partially covered with high grass, it is to be noted that the afforestation of coarse turf may be effected during autumn, as such soil is not so liable to settle down under the weight of snow, and is protected from frost by its grassy covering. Where grass is high and rank, or where heather, furze, and broom replace it, spaces for each plant may be cleared as before mentioned. In this case carefully chosen two-year-old seedlings should be placed at intervals of not less than five feet.

COST OF PLANTING IN STUBBLE OR GRASS LAND.

In the Sologne district of Central France, planting on a large scale can be carried on with such cheapness as has scarcely been imagined in Great Britain. With the best two-year-old plants, one year transplanted, the cost, in stubble or grass land, may be thus estimated, at the very utmost :—

	s.	*d.*	Total cost per acre. *s.*
At 3½ feet, 3250 plants per acre (roads deducted), at 5s. per 1000,	16	3	
Planting do., at 3s. per 1000,	9	9	26
At 4 feet, 2500 plants, at 5s. per 1000,	12	6	
Planting, at 3s. per 1000,	7	6	20
At 5 feet, 1600 plants, at 5s. per 1000,	8	0	
Planting, at 3s. per 1000, say	5	0	13

With three-year-old plants, costing 6s. per 1000, the total cost will be 29s. 3d., 22s. 6d., and 14s. 6d. per acre, at three and a half feet, four feet, and five feet apart respectively.

For seedlings successfully reared in the home nursery, on the system to be described below, the cost should be reduced to, at the very highest, 3s. per 1000. This would further reduce the total cost to 19s. 6d., 15s., and 9s. 8d. per acre. If space has to be cleared round the plants, it should be done for an extra charge of 2s. per 1000; and as it is rough work, and easily controlled, it can be done by contract. Planting work, on the other hand, cannot usually be carried out in this way, so that most estimates of its cost must be approximative, but the above quotations for labour are high, in order to cover any uncertainty.

The planting of small patches, and the filling up of vacancies, are comparatively more expensive than working on a large scale, as more time is lost in carrying on the work. This is, therefore, another reason for choosing good plants, and putting them out carefully at first.

The preliminary cost of drainage and of laying out roads—which are left to be levelled and metalled, if necessary, when the produce of the plantations has to be removed—is insignificant. The average per acre, however, is difficult to calculate, as it will depend on the nature of the soil, some spots requiring no drains at all, and others a considerable number. In a plantation of 550 acres, containing ten miles of drains, the cost, including the lining out of roadways, may be set down at about a penny a yard, or a little over 2s. 6d. an acre. Drains seldom cost much to keep up, as (cattle being excluded) there is but little wear and tear to fill them up, except at crossings; moreover, as hardy pines in a few years drain the soil and subsoil themselves, ditches become more or less unnecessary, although they are still useful for serving the roads along which they pass.

Excluding expenses for fencing, which is not required in Sologne—the only defence to the land being ditches, which are included in the charge for drainage—the total planting expenses vary, in stubble and grass land, from 29s. 3d. (at an exceptionally close distance, seldom had recourse to) to 9s. 8d. for planting proper, plus 2s. 6d. for surface drains and road lining; that is, from 31s. 9d. to 12s. 2d. per acre.

With respect to fencing, it may here be noted that the more compact the ground to be planted is, the less costly will this item become.

PLANTING ON HEATH LAND.

The Scots pine is admirably adapted for planting on soil occupied by heather of any age and strength. No preliminary reclamation of the ground is necessary. Its peculiarly hardy constitution enables it to settle and thrive in such firm soil, and little by little to kill off the heath by the thick cover it affords. In Sologne, for example, under thriving plantations, heather has been all but completely extirpated within a period of ten years.

In Central France, where the ground is generally flat, and free from large stones, planting was conducted as follows:—In the autumn, as soon as the moisture of the season permitted a tool to be inserted into the hard heath soil, pits were opened and refilled with the inverted clod. The bottom earth brought to the surface was broken up by the spade and trodden so that the heather turned down might get to the bottom of the pit. The earth was then allowed to remain exposed to the action of the air, frost, and sun, which completed the work of breaking up and loosening it; and was successfully planted during the following spring, the plants being inserted into slits which were opened with a spade in the loosened soil.

For making these little pits, the cost will vary from 3s. 6d.

to 4s. per 1000. The clod, instead of being at once replaced in the pit, may be left on its edge in such a position that the lower earth is turned towards the north, so as to expose it to the action of the frost, while the heath-covered side is towards the south, so as to be dried by the rays of the sun. In spring the loosened earth could then be crumbled over the roots of the seedlings, and the heath sod placed on the surface.

When heather is very high, a space for the plants may be cleared with the mattock, but this is seldom required, especially if such land has been previously pastured by sheep. The mattock is however very useful where the ground is rough and stony, and the expense of using it should be about the same as in the case of the spade.

Pines planted as above described, in 1874 and 1875, on about 100 acres of arid heath land in Central France, are now, on the whole, in fine thriving condition, notwithstanding a terrible drought in 1876, which destroyed a great number and necessitated replanting. Some of these trees showed last year, when only eight years old, top-shoots more than two and a half feet in length.

Except in exposed situations, vigorous seedlings, two years of age and one year transplanted, can be put down at five feet apart. In the most exposed soils the minimum of four feet apart should not be exceeded, since the thick heather will sufficiently protect them from wind till they are able to take care of themselves.

The expense of afforesting heath land with seedlings two years of age and one year transplanted will be as follows:—

	s.	d.	Total cost per acre. s.	d.
At 4 feet, 2500 per acre, at 5s. per 1000,	12	6		
Pitting, at 4s. per 1000,	10	0		
Planting, at 3s. ,,	7	6		
			30	0
At 5 feet, 1600 per acre, at 5s. per 1000,	8	0		
Pitting, at 4s. per 1000,	6	6		
Planting, at 3s. per 1000, say	5	0		
			19	6

With plants raised in home nurseries at 3s. per 1000, the prices per acre will be reduced to 25s. and 16s. 6d. respectively.

The cost of putting down three-year-old plants has not been considered, as they are not sufficiently stout and compact to be employed for this work.

REPLANTING OLD WOODS.

Of all soils, these are the most difficult to deal with, as the former crop has probably exhausted to a certain extent the mineral and organic constituents of the ground. The old trees, moreover, afford a certain amount of cover for rabbits; and not infrequently destructive insects, such as *Hylobius pini*, are but too common in such cases.

If the soil is arid and sterile, seedlings should be planted not further apart than four feet, and plants of two years of age one year transplanted should be put down.

If the ground is moist and sandy, seedlings of one year may be employed, provided they have been grown in the home nursery in wide drills or lines, and are consequently strong-rooted.

When the land is of better quality, it naturally tends to get covered irregularly with a second crop of birch or other white wood. This comes up in place of the young pines, which grow from seeds shed by those formerly existing. In such cases, therefore, the seedlings must be set further apart, and the thickness and strength of the young natural crop must be carefully considered, as it is useless to plant pines in localities which are shaded in any way.

The number of plants required for this work will be as follows:—

At 6 feet	apart,	1210	per acre.
7	,,	889	,,
8	,,	680	,,
9	,,	537	,,
12	,,	302	,,

About a twelfth is to be deducted for the space occupied by the roads, if these are laid out beforehand.

SOWING OF THE SCOTS PINE *in situ*.

Sowing *in situ* is not usually practised in the United Kingdom, nor could there be any advantage in introducing the method, as the results obtained by careful planting are much superior. It is however possible that, in some of our vast dependencies where labour is scarce, and also in America, where the pine supply is being exhausted by reckless cutting, it might in some cases prove useful, as the plough and the harrow take the place of manual labour. Moreover, planting on a large scale involves the raising at home, from seed, of the plants required.

The Scots pine should be sown *alone.* In Central France it is sometimes mixed with *Pinus pinaster*, but as the latter comes up rather sooner than the former, and grows faster during the first few years, it tends to check the Scots pine, which, as being the more valuable of the two, should be the permanent occupant of the soil. On the other hand, if mixed with *Pinus Austriaca* or any other species, *P. sylvestris* gets the start of and outdoes its companions in its turn.

For work on a large scale, the following method of sowing in lines may be successfully practised, and it effects a vast saving of labour and of seed. With a light plough such as is used for ridging potatoes, shallow drills are drawn at a distance of about four feet from each other. A stick fixed horizontally at right angles to the plough has at its end a line with a plumb, which drags along the ground four feet from the furrow, and thus while tracing each line the position of the next one is indicated. The crop of young trees is thus regulated, and the first thinning facilitated. With this system two or three pounds of seed per acre, according to the natural dryness or moisture of the soil, will suffice. Although this amount may appear small compared with what some authors and most seedsmen recommend, it must be recollected that it contains, at 75,000 to the pound, from 150,000 to 225,000 seeds—certainly enough, allowing for all irregularity, if the thirtieth part come up. The cost of this seed when bought from Highland nurserymen is from 7s. to 12s.; from German seedsmen, from 4s. to 8s.; while in Paris the same amount of Riga variety costs from 9s. to 13s. The last-named variety, it may here be noted, is the best Continental one; it is superior in germinative power to any other, and develops into a very straight tree.

In sowing *Pinus sylvestris* the seed must not be covered more than half an inch at the utmost, and a depth of a quarter of an inch is to be preferred. When too deeply covered, the tender plumule, which rounds itself up, bearing the husk of the seed at its top, has not the force to raise the thick covering of earth, and so cannot get to the surface. In covering the seeds a light hurdle of thorns will prove amply sufficient as a harrow.

Such sowings should be effected in spring rather than in autumn, so that the seed may not lie through the winter at the mercy of birds and mice or other vermin. If the latter abound, powdering the seed with red lead will be found useful.

In light soil covered with grass, and tolerably free from shrubby weeds, *P. sylvestris* may be sown without further preparation than may be effected by merely passing a stout sharp harrow over the ground. In warm climates the best time for this operation is the month of August, as the young plants come up during the September rains, and are not exposed to the summer heats, which, on soil in a condition so unfavourable to a tender plant, they might not be able to resist. As the number of seeds that germinate will be smaller than on ploughed land, it will be advisable to employ four pounds to the acre.

When cutting over young broad-leaved plantations that have failed to cover the ground regularly, or when cutting down old worn-out forests, vacancies may be filled up by simply sowing handfuls of Scots pine seed before setting to work. The passage to and fro of the workmen, when cutting and stacking their wood, will be sufficient to tread the seed into the soil.

The allowance of seed recommended is calculated on the understanding that it is of good quality; it should always be procured without any regard to distance or trouble, and should be obtained from trees neither too old nor too young. Seed from trees showing a weak constitution should be avoided, as the sickliness may be transmitted to the young tree.

Seed should also be got in a *fresh* state, as its germinative power decreases with its age, owing to the drying up of the kernel.

SOWING IN NURSERIES; WITH NOTES ON THE GENERAL MANAGEMENT OF NURSERIES.

For planting on a very large scale, it is indispensable to rear one's own seedlings. Fortunately, as regards the hardy pines, this is a very simple matter, provided it be managed with care and intelligence; and in this connection it may be useful to examine the method of producing good stout seedlings, able to stand the shock of planting out, which has been practised in the Sologne with entire success and wonderful economy.

In choosing a site for a pine nursery, the most important condition is that the soil should be cool and moist. As pines do not suffer from acidity, the nursery may be formed on damp heath-covered ground, provided a sufficient drainage exists to take off all stagnant water; deep drainage is not generally required, since the trenching of itself insures free circulation of air and moisture, as far as the roots of the young plants can penetrate.

If the ground selected is watered by the passage of a stream, or if springs situated above it can be directed into it, and used for watering purposes, the advantage will be great; but this is seldom positively necessary. The Scots pine does not generally require watering, except where the ground is naturally very dry, and it would be very difficult, and too expensive, to carry out such treatment on a large scale.

The slope of the ground should not exceed from five to ten degrees, and should be directed to the north or north-east. This exposure is perhaps less liable than any other to high drying winds and extreme temperatures, which it is absolutely necessary to avoid as much as possible; but local circumstances should be carefully considered in observing or modifying this rule. When ground is too flat it is apt to retain excessive moisture during winter; on the other hand, when the slope is too abrupt, the soil is liable to be washed away by heavy rains.

Pines, which seldom suffer from frost, should, as much as possible, be exposed to the east, and sheltered from the west; the rays of the rising sun, shining through a cool atmosphere, and tempered by the dew on the ground and on the plants, are always beneficial, whereas in dry summers the heat of the long afternoons is hurtful.

If a piece of heath land, pretty rich in humus, and covered either with heather or with stunted wood, be chosen for the nursery, its surface must first be cleared (firing is the best method, if it can be safely employed), and then trenched two spades deep—about twenty inches—so as to bring the lower spit to the surface. This contains no germs of weeds; and the planter is thus delivered from a vast deal of trouble and expense, while the inertness of this deep layer of soil does not in any way hurt the young plants, provided the earth be fine, loose, and retain the proper amount of moisture. The top spit, covered with heath, is thrown to the bottom of the trench, and forms in its turn a subsoil, in which these plants rot, forming humus which, mixed with the top-soil by the gradual settling of the latter, and by subsequent diggings, enriches the whole, and maintains the fertility as long as it is usually required for temporary purposes of planting. Another great advantage of trenching is to be found in the fact that the soil never becomes very dry, as, with a free circulation, the moisture of the subsoil tends to rise to the surface, from the force of capillary attraction.

No previous cultivation, cropping, or manuring is required. The trenching must be done in autumn, as soon as the rains have penetrated the soil and rendered it easy to work. The inert subsoil requires to be exposed to the influence of the sun, air, and frost throughout the winter, in order to become fit for nourishing plants, as in its crude state the constituents it possesses are unfit for assimilation.

If it is desired to stimulate its producing power, 500 lbs. per acre of the following mixture can be employed:—five parts of wood ashes, one part of guano, and half a part of superphosphate. This should be thrown over the ground immediately after trenching, to give time for its incorporation. Such top-dressing, however, will seldom be found necessary.

Farm-yard manure should be avoided, as its excess of ammonia is injurious to most coniferæ; and even when well decayed, it contains germs of weeds, which our system of trenching heath soil is intended to avoid.

In places infested by ground game, the nursery must be protected by wire-netting, which may be of a light and cheap sort, provided the spot be not accessible to cattle. The netting should be two and a half feet high, and its lower edge should be buried about four inches in the ground, in order to prevent the rabbits from burrowing. The width of the mesh should not be greater than one and a half inches, so as to check the entrance of young rabbits. The netting should be put up carefully and evenly, but excessive pulling, which tends to draw it out of shape, should be avoided. The slit made in the ground for its lower edge should be as straight and of as equal depth as possible. For the support of this net simple pickets of iron, two-fifths of an inch thick and one yard long, will be found sufficient if passed through it into the ground. If these are galvanised, so much the better, but the process is expensive ; if not, they can be painted with red lead. For a temporary nursery, intended to last only two or three years, these pickets may be replaced by straight sticks of willow, or, preferably, of alder-buckthorn. It need hardly be added that, if the nursery requires to be fenced from cattle, no special support will be required for the netting, which will be well sustained by the framework of the fence.

With respect to the attacks of rabbits, it is to be noted that their results are comparatively small in pine beds or lines in the nursery, although seedlings of larch and other deciduous trees are readily devoured. On the other hand, young pines which have been planted out are very liable to be destroyed in this way.

SOWING.

Before sowing is begun, the ground is divided into beds and paths. If the soil is cold and heavy, and drainage its chief requirement, these beds may be slightly raised by earth taken out from the paths. In light soil, on the contrary, which dries easily, the passages must be flush with the beds, as the latter are thus less exposed to dry up or to have the soil washed from their sides by heavy rain. One yard is probably the best width for these beds. If narrower, they would not occupy a sufficient proportion of the superficies of the ground, while greater width would be inconvenient for the work of sowing, cleaning, and the like, which should always be effected from the paths, by leaning over, without treading on the beds.

The quality of the seed is a matter of the first importance; and if the forester does not feel certain of it from his previous experience, he will do well to procure samples a month beforehand, and to put them to one or more of the following tests:—

(1) *That of Fire.*[1]—The test in this case is one of the greatest simplicity, and has the advantage of giving in a few minutes the information it can afford—a matter of great importance, as it often happens that seed cannot be received until it is too late for any prolonged trial before sowing.

A number of seeds are taken at random out of the bag and counted. They are then placed one by one on a shovelful of live coals kept on the fire. If the seed burns slowly and quietly, it is worthless, the kernel being decomposed; if, on the contrary, it jumps away with a cracking noise, due doubtless to the expansion of its gases, it may be considered good; and the ratio of the seed on which the fire produces this latter effect to the whole number counted, may be taken as the proportion retaining the power of germination.

M. Digeon recommends this test as applicable to all seeds. It has been tried with success in some cases, and it seems to indicate accurately whether the seeds contain an intact kernel; but it is doubtful if we can tell by this method whether the seed is old or fresh, which is another most important matter.

(2) *That of sowing on Flannel.*[2]—Take a slip of new white flannel, slightly moistened, and in one end of it put up and cover carefully the number of seeds to be tried, then put it on a plate (a soup-plate or large saucer will probably be the best), floating on a trough of water, so that one end of the flannel, by dipping into the water, sucks it up by means of capillary attraction, and so supplies constant and equal

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[1] Described by M. Digeon in the *Journal de l'Agriculture Pratique*, 9th March 1882, p. 328.

[2] Described by M. Martinet in *Journal de l'Agriculture Pratique*, 2nd March 1882, p. 298.

moisture to the whole. Keep up a warm and equal temperature, and after four or five days examine the seeds carefully, noting as *good* those that have sprouted. If germination is slow and irregular, the seed is evidently too old. When fifteen to twenty days have elapsed the test may be considered to end.

(3) *That of sowing in a Flower-Pot.*—Fill a flower-pot, unglazed, and of moderate size, with fine earth, sow the seeds counted, and cover them to the depth of a quarter of an inch, place the pot in an earthenware basin filled with water to a height sufficient to maintain moisture throughout the depth of the earth in which the seed lies, and note the results of germination as before.

(4) *That of sowing on Peat Sod.*—Take a square sod of peat and hollow it out in the shape of a boat, sow the seeds and cover them lightly with the peat-dust removed, then place the whole in a basin, so that the lower part of the turf is constantly immersed, and note the number that sprout.

In trying Continental *P. sylvestris* seeds, if 70 per cent. have sprouted, the result may be considered fairly good, although the French Forest Department exacts 75 per cent. on the seed it receives in large quantities from Darmstadt and elsewhere. The germinative quality of the Riga variety even exceeds this limit, but that of the true Highland pine does not seem to be so good, inasmuch as the kernel, which seems to be smaller, has less sprouting force than that of the Continental varieties. Hence Highland seeds should be covered very lightly, with not more than a quarter of an inch of fine soil.

It may be noted that as *P. sylvestris* is the hardiest species of pine, its seed is that which has the greatest germinating power and which yields the hardiest plants; hence when it is of good quality, and, sown on land carefully prepared, it should infallibly yield a good crop.

When this is not the case, the failure is almost invariably caused by *too thick sowing.* This error is unfortunately common, whether from inexperience on the part of the forester, from the carelessness of the sowers, or from distrust of the quality of the seed employed. When the soil bears double or triple the number of plants that can find space and nourishment in it the crop is worthless. The forester, however, has nothing to gain by excessive production, and the danger of having a crop which is too thin is nothing in comparison with that of its being too thick. *Thin sowing on fresh ground well prepared* should invariably be insisted on.

There are three different methods of sowing—(1) broadcast sowing; (2) sowing in lines; and (3) sowing in narrow strips.

Broadcast or full sowing may be used when the forester intends to transplant into lines during the following season. That transplanting, carefully and judiciously practised, improves the quality of the plants immensely, by exciting the development of fibrous roots, cannot be doubted, yet the proprietor who plants at home, with seedlings always fresh, and not damaged by travelling, or by being long out of the ground, may safely employ untransplanted plants, one or two years old, provided that they are well rooted. To a proprietor, or private forester, who has neither the experience nor the trained staff of workpeople possessed by nurserymen, transplanting is a slow, troublesome, and expensive business. Besides, the season in which it must be done is exactly that in which permanent planting, and the cutting of his woods, employ his attention and labour, so that, in these circumstances, such work cannot be recommended.

Nursery transplanting, therefore, is to be recommended only in the case of seedlings destined to be put down on particularly dry soils, which can only be planted in spring, or in localities where the attacks of the elephant weevil are to be feared, or finally in hard-bound heath soil.

Transplanting may be done either at the end of autumn or in very early spring. The former season is preferable wherever the ground is not liable to open out under the influence of frost, or to settle down under the weight of snow, thereby leaving the roots of the seedlings bare. Trenched ground is generally liable to this objection. In any case, hot, dry spring days should be avoided, and transplanting must be put off until cloudy or showery weather arrives. The seedlings should not be taken up before it is time to plant them; or, if this must be done, as for example in removing from one nursery to another, they must be "*sheughed*" carefully, and their roots must be spread out so that the earth can touch those of each plant. "Sheughing" should be carried out under the shade of trees, or at the bottom of a very dry ditch. If this cannot be effected, the seedlings must be covered with light straw or moss.

The plants are generally put down in holes, opened with a dibble, in rows, which are marked out by a line, and which are about six inches apart, so that the intervening ground may be readily weeded by means of a narrow Dutch hoe. The seedlings may be set two inches apart in the lines. The dibbles should be straight, and shod with steel, so as easily to penetrate into the ground. The roots require to be shortened before being introduced into the holes made by the dibble, and this must be done by a careful person, not interested in the work of planting, if that has been contracted for. They must not be cut too short, in order to get them inserted with the greatest ease and quickness, and the manager may control this to some extent by trying the plants with a slight upward pull. If they come away very readily they are badly planted, and probably would not take. It is essential that they should be well firmed in the soil. Again, they may be put down in little trenches opened out by a gardener's light cleaning mattock. Each trench is filled up by the earth of the one next opened, and the plants are put down carefully, the collar of each being made to hold on to the brink of the trench by a slight pressure of the finger until the trench is refilled. The earth is then lightly but firmly trodden over the roots of the plants. Although this method is not so neat as that of dibble-planting, yet as it does not require root-pruning, and as the earth tends naturally to settle over the roots, it may be preferable to follow it in cases in which the forester is not certain of the ability or trustworthiness of the staff he employs.

DEPTH OF COVERING.

When the whole surface of the bed is sown with a view to future transplantation, it is covered with fine earth shaken over it with a sieve to the depth of about a quarter of an inch.

All seeds require, in order to germinate under favourable circumstances, moisture and a moderately equable and warm temperature. They also require permanent communication with the oxygen of the air. If, therefore, they are buried too deep, they are removed from the action of air and warmth, but if, on the contrary, the seed be insufficiently covered, and if drought follows, the moisture required dries off, and unless constant watering is carried on, germination will not take place, or will not be general. Insufficient covering also exposes the seed to the liability of being washed away by heavy rains.

Experimental forest stations in Germany have determined the best depths for sowing pines. Professor Baur, Director of the station of Hohenheim, sowed in average ground, neither too loose nor too compact, pine seeds, which were covered to various depths, from one-fifth of an inch to two inches. He observed that the seeds buried to the depth of one-fifth of an inch germinated in twenty days, two-fifths of an inch, in twenty-five days, three-fifths of an inch, in twenty-seven days, and four-fifths of an inch, in twenty-nine days. He further observed that seeds buried from one to one and a fifth inches gave little sign of sprouting, and that those covered to a depth varying from one and a half to two inches did not germinate at all. Continuing his experiments for several successive years, he has obtained the following results :—Though seeds covered with one-fifth to two-fifths of an inch of earth come up regularly, the plants they form are somewhat wanting in stoutness, especially where they were least covered. Plants raised from seed buried to rather less than half an inch form a vigorous crop. The beds in which seeds have been buried to four-fifths of an inch remain patchy, and the plants are weak. The young plants, in the case of seeds buried to one and a fifth inches, had attempted to raise the superficial crust of the soil, but had not succeeded in forcing their way through.

At the end of several years all the plants raised from seed buried from one-fifth to three-fifths of an inch are doing equally well; but deeper covering has given less favourable results. Sowings covered from four-fifths of an inch to an inch are too thin; *and at an inch and one-fifth and upwards no plant has survived.* The best average depth for sowing, in most soils, would seem to be from two-fifths to three-fifths of an inch.

SOWING IN LINES.

To sow the beds in lines, a cord is stretched at successive intervals of six inches. A workman may then trace, with a forked stick, having its double end slightly sharpened, and having these ends about two inches apart from each other, shallow drills. In these the seed is sown, at an average distance of about an inch apart, and is lightly covered with a rake.

Seedlings thus raised are certain of having plenty of space and light, each of them being on the edge of the open area between the rows, and they consequently attain fine dimensions.

SOWING IN STRIPS.

If it is desired to raise more plants in the same space, the following mode may be adopted :—

The line being placed as before, at intervals of six inches, drills are formed with the narrow weeding-hoe. These should be about four inches wide, and of uniform depth. The earth taken out is thrown gently on the blank space between the drills. The seeds are now sown, at intervals of about an inch, and the earth is raked lightly over them. This wide distance between the seeds is recommended on the supposition that they are of good quality, and that 70 per cent. of them will germinate; if their germinating power be inferior, they should be sown a little thicker.

SEASON FOR SOWING.

The Scots pine may, under the climate of France, be sown in the month of March. In other climates the forester must be guided by his own judgment, and by the practice he observes around him. Although in early sowings, the plumule, as it emerges from the ground, may be liable to damage from frost, and although some nurserymen sow late in consequence, hardy pines do not often suffer in this way. Moreover, as late sowing exposes the plants in their most tender stage to the heat of the summer sun, this risk is infinitely greater than the former, for even if they escape being burnt up, their growth becomes greatly retarded. Hence the practice of early sowing, if there is a fair chance of success, is to be preferred.

Where mice are troublesome, it is advisable to protect the seed from their attacks, as well as from those of birds, by powdering it finely with red lead, a poison which the instinct of these animals leads them to avoid. This may be done by placing in a stout flat box, of convenient size, a pound or two of the seed, slightly moistened with a few drops of water ; into this some pinches of the red lead are thrown, and the box is shaken until the powder covers each seed. In this way very little red lead is required.

WATERING AND WEEDING.

It is always advisable, wherever possible, to dispense with watering, which, though necessary in special cases, is expensive and troublesome, and may produce very injurious effects if it cannot be kept up regularly (which is difficult to do on a large scale), or if it is done by unskilled workmen, in whose hands it beats and cakes the ground. Pines, which are sun-loving trees, should not, when sown early in deep cool soil, show any necessity for it. In a dry spring it may in some cases be advisable to water at the moment of germination only, in order to prevent the young plumules from being burnt by the sun ; but the same result may be attained by covering the blank space between the rows, at the time of sowing, with layers of moss about two inches thick, in order to shelter the soil and keep it cool ; or by sticking in on the southern edges of the beds, and slanting over them, branches of broom or fir, which moderate the heat of the sun by the varying shade they afford, without drawing up and weakening the plants as direct cover would do.

As to weeding, it may be noted that excellent pine nurseries may be made in trenched heath soil, and kept without cultivation of any sort during two years. In such inert ground weeds are but little to be feared, and if some do make their appearance, they perhaps make up for what they take from the soil by the shelter they give the young plants. There are however two sorts which cannot be tolerated, namely, the groundsel, which harbours in its early stages a fungus destructive to young pines, and which fruits in a very short time, and the *Rumex acetosella*, a small sorrel with arrow-shaped leaves and red spikes of flowers. This sorrel is fond of acid land, and when once it has gained footing there it grows with extreme rapidity, throwing out in all directions a network of knotty subterranean stems, which bind the soil, and each of which sends up numerous shoots.

Weeding between the rows with a light hoe about three inches wide is very useful, not only for destroying weeds, but for loosening the surface soil, and opening it to the action of air and moisture. This work should if possible be done just before rains, as it enables these to penetrate the soil more readily. If the weeds have been allowed to grow high, it is dangerous to take away suddenly the cover they afford to the plants, when the weather is hot and dry; it is better to wait for a rainy or cloudy period.

MANURING.

If the nursery is destined to last some time it is necessary to maintain the fertility of the soil. It is a serious mistake to suppose, when intending to plant poor land, that the seedlings should be hardened and rendered suitable for the purpose by being reared in soil of the same quality. In reality, the growth of plants in their early stages takes much more out of the soil than the growth of wood, 1*st*, because young plants feed almost exclusively on the surface soil, and 2*d*, because the crop of plants is always exported; whereas trees restore to the ground, by means of their detritus, more or less of the elements assimilated by them.

It is calculated that an acre of nursery under pines one or two years old requires annually about the same quantity of potash as an acre of rye, about a third more lime, and a little less phosphoric acid. Nursery soil should therefore be manured as well as farm land, and the mixture above recommended—namely, five parts of wood ashes, one part of guano, half a part of superphosphate—is suitable for that purpose. Nitrates and highly ammoniacal manures must be avoided. Composts made with cleanings of old ditches, weeds pulled up before seeding, and the like, are excellent when well rotted;

their employment, however, as well as that of farm-yard manure, has the disadvantage of stimulating weed growth, and it is better to avoid these in temporary nurseries which can be kept up long enough with artificial manures.

When required for planting, the seedlings should be pulled up with the greatest care by experienced workmen, and all precautions required to avoid breaking and peeling of the roots should be exercised. Long sharp spades should be used for this purpose. If the plants cannot be put out at once, they should be laid down thinly under shade, and their roots covered with fine earth, so that each of them may be in contact with it.

INSECT AND VEGETABLE PLAGUES.

We do not know of any internal organic disease to which the Scots pine is liable, but it suffers from the attacks of a certain number of insects and of fungi. These plagues may be considered successively, in the same order as that in which they affect the growth of the tree, from its earliest youth upwards.

The first enemy of the pine, and one which attacks the young plants at the age of a year and upwards, is *Œcidium pini*, the Pine-cluster Cup, the *rouille des pins* of the French, or the *rust disease*. It is a microscopic fungus living on the leaves, which become of a reddish-brown colour and fall off, whence the name of rust applied to the malady. It is not entirely confined to young plants. In the spring of 1881 a whole series of our young plantations, from the age of three or four years to that of ten, had their leaves completely dried up, as if fire had swept over them. These plantations, it must be explained, were then in poor condition. They had been suddenly deprived of the shelter of some Pinasters that had been mixed with them by the extreme frosts of 1879-80, and subsequently to the cutting of the nurse wood there came a period of particularly high drying east wind.

Mycologists who have studied this parasite have ascertained it to be a tertiary form of *Colcosporum senecionis*, a polymorphous fungus propagated on groundsel. On this plant it bears numerous spores of different forms according to the season, *uredo* spores in summer, *teleuto* or *resting* spores in winter (so called from their lying dormant during that season). These spores develop in a secondary intermediate form on the ground, and finally form microscopic orange-coloured cluster-cups on the leaves of the young pines in their vicinity. The mycelium, penetrating the tissue of the leaves, forms, as it were, partition walls across them, and thus suspends the circulation and aëration of the sap, and the nourishment of the plants carried on through the leaves, which dry up, and finally fall. The roots also suffer, and their fibres die off from the want of the sap usually elaborated by the leaves. The mycelium drops, in the month of May, with the leaves it fed upon, and the young tree generally puts out new ones and recovers, though its growth is more or less checked. Hence, though young plants are not killed by this pest, they are so weakened as to become unfit for transplantation.

The chief damage done is in old nurseries worn out by exhausting cultivation and on poor soils. Wherever this fungus appears, therefore, it is necessary either to abandon the land which bears it, or transform it, where possible, by deep trenching and liberal treatment with manure and compost.

Great care must also be taken to employ only fresh and healthy seed. As, moreover, the fungus originates on groundsel, this weed should be kept down, not only in the nursery, but on the surrounding ground.

That the growth of this pest, however, is accelerated by a lack of vigour in the plants affected, and that stout healthy seedlings resist its attacks most successfully, is not improbable. It usually appears in very thick sowings, where the plants are long-drawn and weakly ; so that for this reason alone thin sowing should be insisted on.

The Great Weevil, or Elephant Beetle, *Curculio* (*Hylobius*) *pini*, attacks only young plants used for restocking old pine woods, or planted in ground contiguous to them. Whole fields of seedlings are often destroyed by this pest. It is a coleopterous insect, with a trunk-shaped snout, like that of all the " rhyncophorous " (beak-bearing) tribe, to which it belongs. To this protuberance is also due its name of Elephant Beetle. It is about half an inch long, and its wing-cases are dark brown, with patches of hairs forming yellow spots.

In the months of May, June, and July the female lays her eggs in the dead stumps, sometimes at the foot of dying trees. The larvæ very soon effect their transformations, and become full-grown insects, which attack the young plants, choosing those from three to six years old in preference to others.

The weevils creep up the young pines, eating their bark from the collar upwards, and sometimes their shoots also. If they are observed, and are in danger of being caught, they drop into the thick grass, where they hide themselves. They are heavy and indolent, and, though possessing wings, seem never to attempt to fly once they have chosen their locality for the season. During the heat of the day in summer they come down into the grass to take shelter from the sun, and this habit enables us to destroy a certain number of them. At intervals of ten yards every way, little spaces, two feet long by one foot wide, are cleared and raked up. These they haunt, on account of the coolness of the loosened soil. On each of these spaces a miniature fagot of green pine twigs, about 18 inches long and the same in circumference, is put down and somewhat flattened by treading on it. These fagots are lifted and shaken every afternoon, and the insects which have crept under them, and are inactive, allow themselves to be taken without any attempt to escape. With these fagot-traps hundreds of these weevils may be caught, but as their numbers are so immense, the results obtained are insignificant. Still, although no effective cure has yet been found for this weevil, prevention is possible, if set about in time. Since it is in the stumps of pines recently cut that they are propagated, those that are fresh or in good preservation should be extracted when there is any likelihood of an invasion. Once rotted, the insects do not breed in them, and they may safely be left in the ground.

Mr. M'Corquodale,[1] forester at Scone, Perthshire, has succeeded in averting the attacks of this pest, by smoothing the soil with the back of the spade around the newly-planted tree, as the work of afforesting proceeded, the insect being thus deprived of the shelter of grass or loose earth in which it delighted.

The formidable invasion of weevils, as well as other insects, which swept over the Sologne district from 1880 to 1882, and from which some stragglers still remain, was due to the complete and simultaneous destruction of the Pinasters, which formed three-quarters of the whole woods of the country. The cutting of these dead woods was a work of great labour and expense, and to uproot the dead stumps was of course impossible, so that the development of insects of several sorts attained such vast proportions, as it is not likely to equal in future under ordinary circumstances.

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[1] *Forestry*, April 1884, p. 448.

Pissodes (*Curculio*) *notatus*, or the Speckled Weevil, is another rhyncophorous insect of smaller size than the elephant weevil, and spotted with brown and white specks, whence its specific name. This insect appears in the month of May, and generally breeds in the stumps of pines previously cut. But it is in the larval state that it does most damage, by boring runnels downwards, from the first whorls of the plant to the collar, in which region it generally forms a chamber, where it becomes transformed into a pupa. When several larvæ bore their runnels on the same plant, they suffice to kill it. Sometimes the winter is passed in the larva or pupa stage, but it generally becomes a perfect insect in autumn, and winters in the collar and roots of the young plant.

The only means of averting their ravages is by carefully uprooting dead stumps and dying trees.

Hylesinus (*Hylurgus* or *Scolytus*) *piniperda* (Fr. *Hylesine*, *Hylurgue*, or *Scolyte des pins;* Germ. *Wald-Gaertner*, Forest Gardener).—This is a little coleopterous insect, black or dark brown in colour, and hardly a quarter of an inch long. Its prothorax is narrowed towards the head, and this peculiarity distinguishes it from the Bostrich, which it otherwise closely resembles, but whose body is of the same width all over.

In April or May the females choose dying trees in a pine wood, or those overthrown by gales of wind, in which they deposit their eggs. Entering at the base, the female bores till she gets between the liber and the alburnum, and then ascends, forming a runnel, in which she deposits, on an average, about 120 eggs.

The larvæ make secondary runnels, and feed on the substance they displace in so doing. In due time they hollow out small chambers in which they imbed themselves, to effect their transformation into pupas.

The fully-developed insects issue from these chambers about the beginning of July—sooner or later, according to the climate and the weather,—and transfer their destructive operations, which had previously been carried on under the bark, to the medullary or pith tubes of the shoots aged from one to three years. Each insect bores a hole sufficient to allow of its entrance at the base of a young shoot, and ascends the pith tube, feeding on its substance. When it comes to the bud at its extremity it issues, and begins the same work on another young branch. The shoots dry up, hang downwards, and finally fall as if they had been cut with shears, whence the name of "Forest Gardener" given in Germany to this insect. These operations continue until the first frosty weather arrives, generally in November, when the insects drop from the trees, and lie hidden among the moss and weeds, or under the pine leaves at its base. Most of them are supposed to die, leaving only a certain number to propagate the breed; but it is certain that a sufficient proportion of them survives to do a certain amount of damage to the young branches in early spring, before they enter the bark of the dying trees for the purpose of breeding. The damage done at this season, however, is seldom very important, the time when most harm is effected being in summer and autumn. We have never seen healthy trees killed by this insect, but the loss of their young branches and leaves checks their development for some time, and entails the loss of the growth of a year or two. Moreover, the leading shoot is sometimes destroyed, and the tree becomes consequently deformed. It is prudent to get the shoots which fall from the trees raked up and burnt during the month of August; for although the insect has abandoned those that are quite dry, it is sometimes to be found in those which, remaining green for some time, fall by their own weight. It is to be observed that prevention of this pest is practicable to a certain degree by clean working of the plantations.

Since the females lay their eggs only in decaying and dying trees, or rarely on broken limbs or unbarked cut wood, in which there still remains a little sap—dry wood being too hard for their boring work, and the flow of sap in green wood, even where it is weak, being sufficient to choke the insects, and to drown their larvæ,—it is clear that all decaying and dying wood should be removed. Decayed trees, that still stand, should be cut down during winter. In the beginning of June all the young plantations should be carefully examined, and all the trees which contain broods of insects cut down. These are easily recognised by the yellowness of their leaves, and, when examined closely, by the presence at their base of heaps of detritus which has fallen from the insects' runnels. Very young trees which are of no value should be removed to open spaces or to roads, and burned along with the larvæ they contain, great care being taken that the fire does not spread to the trees around.

It is desirable that these measures should be simultaneously carried into effect by all foresters in cases where woods suffer from this plague, yet it is to be borne in mind that, as most of the mischief done by the *Hylesinus*, like that wrought by the elephant beetle, is confined to the neighbourhood of its breeding-places, such measures, taken even separately, will prove of great use.

Bostrichus chalcographus, *B. stenographus*, and *B. bidens* (*Hylesinus ater*), are much more formidable enemies to pines than *Hylesinus piniperda*. *B. stenographus* is about the size of the latter; *B. chalcographus* is only one-eighth of an inch long, and *B. bidens* about one-twelfth of an inch. The body of these insects is of about the same thickness throughout, and the extremities of their wing-cases are cut away diagonally in an upward direction towards the head.

These pests appear, like *Hylesinus piniperda* (which they closely resemble, with the exception of the above peculiarities), in the month of May. The females lay their eggs in the same manner in dying trees, and in wood recently cut if it possesses a thickish bark. The special characteristic which renders them so formidable is the appalling rapidity of their propagation. The new generation develops in the same way as that of *H. piniperda*, but with such quickness that it has often time to breed in its turn, and the second brood appears in great numbers during the months of July and August.

Whether as larvæ, or as full-grown insects, they always attack the trunk of the tree, and bore in the liber and alburnum the peculiarly-shaped runs from which they derive their specific names of *stenographus* (short-hand writer), and *chalcographus* (engraver). Their numbers often become so enormous as to destroy whole districts of forest. Trees attacked by them are honeycombed with little holes, like those produced by a charge of the smallest shot.

The true way of preventing such invasions is the same as that which we have just recommended in opposing the attacks of *H. piniperda*, that is, the taking out, cutting up, and barking, of all diseased and dying trees. This work ought to be finished earlier in the season, on account of the more rapid operations of the Bostrich, and the wood thus cut should be carted off or carbonised as soon as possible.

The Round Disease (Fr. *Maladie ronde*) is a disease usually considered special to *Pinus pinaster*, and is the work of a fungus whose mycelium penetrates into its roots. Scientific authorities are not agreed as to the particular species, whether it be *Tramœtes radiciperda*, *Agaricus melleus*, or *Helvella acaulis* (*Rhyzina undulata*). When the first tree attacked by this fungus has succumbed, the infection is communicated to its neighbours, which also die off. Those contiguous to them are attacked in their turn, and the disease continues always spreading in concentric circles. This malady, which necessitates the cutting down of many forests of Pinasters, generally appears subsequently to the lighting of fires, and chiefly to charcoal-burning. Scots pines mixed with Pinasters, as is customary in many parts of Central France, took the malady from the latter (after resisting it for some time), though as a rule they are not subject to it when standing by themselves. Sometimes, however, cases have occurred in which woods consisting of Scots pine alone have been attacked by this disease; but it is exceptional, and spores may have been transmitted from neighbouring woods of Pinasters. The Scots pine may be subject to its attacks when its condition is unhealthy. Even in the case of Pinaster, rational cultivation, by means of early, moderate, and progressive thinnings, diminishes greatly the chances of this malady, if it cannot completely prevent it, and the same judicious treatment applied to *Pinus sylvestris* will probably enable the tree to withstand it with perfect success.

MANAGEMENT OF YOUNG PLANTATIONS—THINNING AND PRUNING.

Once pine plantations have grown so as to cover the soil, the whole secret of their cultivation lies in the successive thinnings they receive. A certain amount of light and heat are absolutely necessary to the pine at every stage of its existence, and this allowance thinnings are intended to give, so that, besides the pecuniary advantages of their yield, their cultural function is of the highest importance.

When trees are raised from seed it is of course necessary to thin them sooner than when planted. The number of trees obtained by sowing is generally excessive, and more or less irregular; but even where they have come up thin on the whole, there may be, in some parts of the plantation, patches much thicker than the average growth, owing to the fact that the young pines have come up better, or grown faster, than their neighbours. It is therefore advisable to pass through all such plantations at an early stage, and thin all trees that are beginning to be too thick on the ground, whether this be the general condition or an exceptional one.

It is impossible to say exactly at what age the first thinning becomes necessary. The time for it will vary according to the distances at which the young pines come up, and the growth they make. This observation holds good with regard to planted pines, as well as sown ones, though the former, as a rule, cannot require thinning so soon as the latter.

When left too long unthinned, pines run great danger of being drawn up, and becoming weakly, the space each one has on the ground being insufficient for the spread of its roots and of its branches. When pines have been allowed to get into this state they must be thinned with the greatest caution, for it is only their mutual pressure on each other that keeps them up, and when that is taken away at once, not only does their general health suffer from the exposure caused by the sudden removal of their accustomed shelter, but they are liable to be blown over by high winds, and weighed down by heavy snow. Few trees should be taken out at a time, and the process should be renewed every year until the plantation can be left sufficiently thin without fear of any ill effects. It is however unpardonable to leave young pines until they get into such a state, for their recovery from it is always long and difficult, and the consequent loss of wood-production great. The first thinning should take place while they still retain, to some degree, the conical shape natural to young pines, being clothed with branches from near their base to their summit; they are then vigorous and well balanced, and are able to resist violent winds, except where the land is water-logged and their roots have a very imperfect hold in it.

Thinning should be repeated every two, three, or four years, according to the vigour of the growth, and until it begins to slacken; the weakest and worst-shaped trees should be removed, and none but straight, stout, and healthy ones should be left on the ground. The system recommended by Dr. Brown[1] is excellent. It consists in dividing the plantations into two, three, or four sections, and thinning one of these each year, thus securing at the same time steadiness in work and regularity of produce. In carrying out this work very careful supervision is necessary, as well as judgment in selecting the straightest and stoutest trees. In France thinning is generally done by task work, as it is recognised that day labour is too slow and expensive. But a man who is taking down trees by the task is always tempted, unless carefully watched, to swell his pile of wood by cutting the best of them. It is essential, therefore, that the forester or his subordinates should mark every tree that is to be taken out. If it is desired to mark the first thinning, the dead or dying branches which make a thicket of the plantation can be previously cleared away, at a rate agreed on with the workmen, and fixed either according to the number of fagots made, or else to the amount of space gone over. The work of marking is thereby facilitated.

As to the space at which the trees should be left, Dr. Brown states as a good general rule that this should equal one-third of their height at each successive stage of growth. Thus a tree six yards high should have six feet of space to stand in, and so on proportionately. These distances can only serve for general guidance, because regularity of distance is a very secondary affair compared with the vigour of the trees left. Thus when, as sometimes happens, the two best pines of a clump stand close together, we must leave both of them and thin out the poorer ones around so as to give plenty of room to each.

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[1] *The Forester*, 4th edit., p. 552, *et seq.*

Again, *Pinus sylvestris* is a very wide-spread species, and presents a very large number of varieties, of which certain ones show such very marked distinctions that some botanists have considered them worthy of being ranked as distinct species. From the forester's point of view, moreover, the difference shown by these varieties in their habit and growth is of the greatest practical importance, and it is much to be regretted that the selection of the seed from which plants are raised has seldom received sufficient attention. As an instance in point, we observe in our own plantations certain clumps of *Pinus sylvestris* which show straight and regular growth, although they came up at about seven feet apart, while others close to them, planted at distances of only a yard and a half, show a tendency to straggle and grow bushy wherever their branches can find an open space to encroach upon. It is evident that in the first case we can thin boldly when required, without fear of our pines straggling in consequence, whereas in the second, thinning must be done very cautiously, diminishing little by little, but constantly, the lateral pressure, without which those trees would never grow straight.

While making allowances for this and all other practical circumstances, it is to be remembered that the Scots pine, especially in poor and shallow soils, which it is generally employed to utilise, and where it finds but few resources, draws the greater part of its nourishment from the atmosphere by means of the abundant leaves borne on its sturdy branches. It therefore requires abundance of space and light, without which the leaves could not develop vigorously, and the object to keep in view in thinning is to favour this development as much as possible without allowing the tree to straggle or grow crooked, or make branches of disproportionate thickness. It is thus that the forester obtains stout healthy trees, capable of resisting the violence of winds and the weight of snows, and yielding in the end a bulk of wood much exceeding that to be got from any number of lanky, drawn-up, weakly forms, the bulk of wood in a tree increasing in proportion to the square of its diameter.

It is not however to be supposed that what a tree gains in thickness it necessarily loses in height, at least during its youth, when its growth is most rapid. On the contrary, where pines are grown at proper distances, the stoutest among them, and those most regularly clothed with healthy branches, are also those that make the longest top-shoots. If some trees form exceptions to this rule, it is generally because they grow in open spaces, and along the sides of roads, where they sustain no pressure from their neighbours.

The irregular habit of growth observed in certain varieties and individuals of this species, renders it difficult in their case to obtain the maximum yield of wood combined with straight growth. In these circumstances, as in most others, it is necessary to study the habits of the tree, the capabilities of the soil, and the market to be expected, and to modify, according to all these causes, the application of the general rules, whose principles should never be lost sight of. To guard against this irregularity of growth, it is highly expedient to make a careful choice of seed and plants, and to employ, whenever possible, the varieties of *Pinus sylvestris,* which form the straightest trees without having to grow in close order—an arrangement which is hurtful to the constitution of the pine.

A further object in thinning gradually and prudently is that of preserving cover on the soil, which it would be imprudent, in warm climates especially, to expose suddenly to the broiling rays of the summer sun, as the trees themselves might suffer from the change, and consequently become liable to the attacks of insects.

PRUNING.

The following fundamental rule, given by Dr. Landolt of Zürich, should never be lost sight of :—

"In a plantation of regular growth, in which all the trees are of the same age, pruning should be confined to dead and dying branches, and to those which threaten to bring about a malformation of the stem."

Pruning is essentially a surgical operation; it is not an ordinary hygienic measure. It may be useful, when applied to isolated trees, to those planted in lines, or to those reserved above copsewood, in short, to those which are not kept in shape by the pressure of their neighbours, and which tend to straggle and occupy more room than they ought to have; but masses of trees of the same age, planted at proper and regular distances, have generally no need of it. This applies to all plantations, but is most strictly applicable to resinous trees, to which the lopping of green branches is particularly hurtful, causing considerable loss of sap, which exudes for a long time from the wound, and more or less injuring the cortical system.

The sap, drawn up in its elementary state by the roots of the tree, rises through the cells of the stem and branches, and passes into the leaves, where it comes in contact with the air, which enters by means of the stomata. Here modifications under the influence of light take place, carbon, which is obtained from the carbonic acid in the atmosphere, being assimilated. Descending again, it passes partly between the soft bark and the wood, in which region the cambium forms the young wood or alburnum, and ultimately reaches the roots and nourishes them. Hence it is clear that the sudden loss of its leaves, which are essential organs in this work, playing the part of the lungs in the circulation of our blood, and that of feeding mouths as well, must cause the greatest disturbance to the system of the tree, and be eminently hurtful to its development. It is indeed well known that when we sacrifice more or less of the leaves of a tree, we sacrifice a proportional part of its capacity for wood production. The pruning of fruit-trees is practised with that very object, so as to weaken their growth and make them "run to seed." In the case of some broad-leaved forest trees suffering from temporary ill-health, pruning, as a surgical remedy, is thus justified, inasmuch as, by removing sickly branches bearing weak stunted leaves, the formation of young healthy ones bearing larger and more vigorous leaves is excited.

With pines no such adventitious growth takes place. In their case, the removal of so many green leaves means so much less assimilation and wood production. The pruning of green branches of pines can therefore only be justified when we knowingly sacrifice a certain proportion of their growth, in order that the rest of it may be better directed.

In France, proprietors of young pine woods, principally raised from seed, and consequently soon getting too thick, have been known to attempt to clear them for the first time by pruning instead of thinning. This is a dangerous mistake, for the objects of the two operations are directly opposite: that of thinning being to give the trees left more room to stand in; that of pruning being to reduce the space they cover. It is therefore evident that one of these operations cannot replace the other. Thin straggling trees, and they will grow still more bushy; prune crowded ones, and they will grow still more lanky and weak.

It may be further observed that the removal of the lower branches of pines has another bad effect, namely that of diminishing the cover, and thus favouring the growth of heather and other weeds, which would be smothered by the normal development of the foliage.

At the first thinning, however, the dead or dying branches should be removed. They oppose the movements of the workmen; and, later on, they form knots in the trunk wood, their bases becoming enveloped by the annual rings of growth of the tree, which are formed between the wood and the bark.

It is also necessary to remove those branches which "threaten to give rise to a malformation of the stem," whether they be half-upright branches or second stems in young pines only, which would ultimately form double trees, and which result from the loss of the top-shoot at a previous stage of growth. These cases of malformation are generally found on the trees along the edges of the plantation, or of its roads; or in open spaces where they have had no pressure from their neighbours. They can be boldly corrected if the young pine, deprived of those branches, has a sufficient amount of foliage left for its requirements. When double stems occur in the interior of a plantation, they should be left, if they are both equally fine; for during the youth of the tree, when it gets much food from the atmosphere, it can maintain for a certain time this double growth, and, later on, the whole tree can be cut out on the occasion of a future thinning. On the edges, where such a formation gives rise to straggling, the second stem may be shortened, in the first instance, so as to avoid depriving the tree at once of many of its leaves. The remaining shoot now takes the lead, and nearly all the sap—after the first loss from the wound—is directed into it; so that in a year or two, or at the next thinning, the shortened shoot can be cut away without much loss of sap. "Gormandising" branches are in the same way shortened back, and finally cut clean off, if they are stout; if very young, they can be completely removed at once.

Lastly, pruning is useful where it is desired to weaken a tree (*e.g.* a pine), in order to resist its encroachments on other species planted along with it. If it is intended to preserve the pine, its branches must be shortened, and a few green twigs left on them to draw the sap, so that they may not completely die off.

MIXTURE WITH OTHER TREES.

Scots pine, as a rule, is not well adapted for planting along with other trees. The quality which makes this pine so valuable for utilising rough waste land, namely, its extraordinary faculty for taking possession of the soil and purging it of all other vegetation, makes it a very bad nurse indeed. Even if its vegetation be weakened, and its cover moderated by dint of severe pruning, its powerful roots still occupy the soil, and tend to exclude those of any other plants.

In Central France, as already noted, it has been usual to sow *P. sylvestris* and *P. pinaster* together, but the latter comes up faster than the former, and tends to check it. The practice is not to be recommended.

With the Austrian pine, and with any other conifer, *P. sylvestris* takes the lead in its turn, and the rest are crushed. Hence the only admixture that can be recommended is one of the faster-growing sorts of Coniferæ, such as the Corsican laricio and the Weymouth pines, the spruce fir, the Douglas fir, and the larch. These could be planted on the edges of the roads, so as to give variety to the view. Such species, however, should be planted with care, and be given at least a year's start on *P. sylvestris*, as they generally hang back a year or two after planting. These young trees, moreover, must be attended to as the plantation grows, and freed from the encroachments of *P. sylvestris*, by pruning the latter, or by cutting it out, when this can be done without interrupting the regularity of the plantation.

As a nurse to young broad-leaved trees, larch, Corsican laricio, or *P. pinaster*, is to be preferred to Scots pine, according to the soil and climate in which such plantations are to be formed. It must be remarked however that when *P. sylvestris* has grown high, and its cover, as well as its network of roots, has become less close, in consequence of successive thinnings, a natural underwood of broad-leaved species appears if there are any seed-bearing trees of the latter at hand. Such trees might with this view be planted beforehand along the roads or outer margins of the plantation, taking into account the prevailing directions in which the winds will disperse the seed.

PRODUCE AND MANNER OF WORKING.

The usual manner adopted in working pine forests is to thin successively until maturity, and then to cut down completely.

When a small plantation is either a little more or a little less advanced in growth than those continuous with it or adjoining it, the forester should either hasten or delay its thinning for a year or two, so as to be able to work it regularly with the rest, rather than make small cuttings, isolated and out of the way, which are the most troublesome and the least profitable. The final cutting should take place when the trees have arrived at maturity, as no profit will result from keeping them on the ground. The date at which a tree may be cut down may be ascertained from the following considerations:—

Its growth is most rapid during the first stage of its existence; it becomes stationary, *i.e.* remains equal, in succeeding years, neither increasing nor diminishing; then it gets less and less in the last stage, and finally ceases, when decay supervenes. The time therefore at which it can be most profitably cut down occurs when the growth has attained the slackening period, and will henceforth, if the tree is kept standing, give results inferior to the average yearly growth of its whole life. If felled before this particular date, some of its best growth will be lost; if after it, any increase will be inferior to that of a young tree coming on in its room. It may be useful to take note of this rule as a principle, though in practice it is subject to modification by many circumstances, such as the inequality in growth and vigour of different trees in the same wood, the quality of the timber, and the difficulty and expense of re-stocking in the natural or artificial way. At the final cutting some of the best and straightest trees should be left as seed-bearers. They should also be the stoutest, so as to resist the violence of winds.

From plantations of no great age, little large-sized timber can be obtained, and their principal produce consists of fagots, charcoal wood, *cotrets* (bundles of split wood, some four feet long and two and a half feet in circumference, which are used by French bakers for heating their ovens), mining props, and railway sleepers.

Fagots should be carefully examined, one here and there being taken out of the heaps, and measured with a tape, to determine whether it is of the circumference required, and they should be well and tightly tied. All fagots and other thinnings should be piled along the roads, so as to be easily removed by carts.

Charcoal wood is familiar to every forester, and the manner of making it may vary according to the local demand. *Cotrets*, on the other hand, are confined to France, where they are used for bread-baking. In making these, it is necessary to remove the bark, in order to prevent fouling of the oven. Where saleable, they form the most valuable produce of young pines.

Mining props are generally in good demand, and pay very well in Northern and Central France. But they require to be very carefully made, in order that they may be willingly accepted by the buyer, and that all disputes as to their quality and dimensions may be avoided. The conditions of the bargain must be clearly defined, and thoroughly understood by the workmen. These usually involve definite requirements as to length and minimum diameter at the small end; the degree of curvature allowed is stated, while the complete smoothing off of branch-bases and knots, and the perfect preservation of the wood, are insisted on. It sometimes happens that the small end, if cut near a whorl, where the wood swells, is thicker than the portion immediately under it, which may, therefore, measure less than the apparent minimum diameter. This end, moreover, is sometimes oval, and has consequently two different diameters. If, therefore, a minimum at the small end has been stipulated, will the whorl-bulging be accepted, and must the smaller of the two diameters of an oval end be taken? As the prop made of green wood shrinks when dry, some allowance must be made for this loss of bulk. To avoid all disputes, and even possible lawsuits, it is necessary that all such questions should be clearly defined in the written contract.

Railway sleepers also have to be of sound wood and careful manufacture.

Pine wood is now employed in the paving of streets. It is just soft enough to allow sand, grit, and gravel to be trodden into it—a circumstance which prevents horses from slipping so readily as they would do on the bare surface of the wood. Pines grown in France cannot as yet furnish wood hard enough for paving, but that of Scotland may possibly be sufficiently hardened for the purpose.

VARIETIES OF PINUS SYLVESTRIS.

When planting this tree, or when forming a nursery to rear its seedlings, it is important to grow those varieties which attain the finest development and yield the most valuable timber.

Foresters fortunately have a valuable guide to this question in the long and careful studies of M. de Vilmorin, carried on from 1821 to 1862 on his estate of Les Barres, Nogent-sur-Vernisson, in the Department of the Loiret, which was purchased at his death by Government, and is now kept up as a

Forest School. His observations are very fully described by Dr. J. Croumbie Brown.[1]

M. de Vilmorin raised and cultivated thirty varieties of *P. sylvestris*, paying special attention to the practical usefulness of each, and classing them according to their conformation, the direction and the bulk of their branches, and their proportions, rather than with regard to their botanical peculiarities. As he remarks, the latter might vary considerably, the form of the leaves, fruit, and flowers might be very different among trees equally valuable for the quality and bulk of their wood; whereas, between a pine of an elongated trunk perfectly straight, with a regular head, and one with a crooked knotty trunk, with a head diffuse and spreading, there is all the difference between a very good tree and a very bad one. He therefore classed his pines in two Divisions and five Sections, as follows:—

DIVISION I.—Trees with ascending branches. Type, *P. sylvestris*, var. *rubra*.

- Section A. Branches ascending, close, and pyramidal, *e.g.* Riga pine, first variety.
- Section B. Branches ascending, but scattered; top regular, *e.g.* Riga pine, second variety.
- Section C. Branches ascending, but scattered; often *gourmandes* or overgrown, as if feeding rapaciously on the sap of the tree; top irregular, *e.g.* Haguenau or German pine.

DIVISION II.—Branches horizontal. Type, *P. sylvestris*, var. *vulgaris*.

- Section D. Branches horizontal, in successive layers or stages, light, but irregular, *e.g.* Geneva pine, tapering, but straggling.
- Section E. Branches horizontal, but thick and compact, *e.g.* the Geneva pine, called the Briançon or Higher Alps pine.

It seems that, as a general rule, each variety grows straighter and more regular, according as its habitat is further north;

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[1] *Pine Plantations on the Sand Wastes of France.* By Dr. J. Croumbie Brown. Edinburgh: Oliver and Boyd. London: Simpkin and Marshall, chap. ix. pp. 103 *et seq.*

as if in warmer climates the balance of the economy of the tree was more or less interfered with, to the deterioration of its general conformation.

The official Catalogue of trees and plants on the Government estate of Les Barres, issued in 1878, thus describes (page 51) the Riga pine:—

Of all varieties of *P. sylvestris*, the Riga pine is the most handsome, and undoubtedly deserves preference. Its trunk is perfectly upright, and attains great height, always remaining more or less cylindrical; the lateral branches are not numerous, and never become very large, nor are they sufficiently developed to cause a malformation of the stem, as often happens with the Haguenau pine. The bark is quite red from about five feet above ground, and comes away in scales as thin as leaves of paper, under which, at less than one-twentieth of an inch, appears the inner green bark.

The shoots, says M. de Vilmorin, are more forward in spring than those of the Haguenau, and much more so—often to the extent of fifteen days even—than those of the Geneva pine, the pine of Ardêche, and those analogous to them. They are of a pale green hue; the leaf is not so glaucous, so long, nor so straight as that of the Haguenau, and it stands more erect against the branches. It is, on the contrary, longer and narrower than those of the Geneva variety.[1]

With regard to planting the Riga pine, it is encouraging to know that this variety is the easiest of all to transplant, and the one which gives the greatest likelihood of success when put out in forest land. In the nurseries of Les Barres, and in other private establishments, the Riga beds are always the most regular, and make the strongest growth.

In Section A, of which the first variety of the Riga pine is the type, M. de Vilmorin includes four Russian pines,—those of Smolensk, Vitebsk, Tchernigov, and Volhynia.

In Section B, represented by the second variety of Riga (less pyramidal than the first), he classes a variety from Louvain, which, however, is supposed to be of Russian origin.

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[1] The Catalogue above quoted further remarks that it is most desirable to substitute, in general forest use, plants raised from Riga seed for those obtained from German seed, as the latter comes from trees of mixed types, more or fewer of which are defective in form.

This (with the experience of Les Barres, where a second generation of Riga pines, raised from seed collected on the estate, shows no falling off in growth or form) appears to prove the constancy and distinctnesss of the variety, even when grown under a climate which is not that of its natural habitat.

Several pines, and notably the Scots Highland pine, are classed as intermediate between Sections B and C. We have only raised small plants of this pine in our nurseries; its seed is infinitely inferior in germinating power to that of the Riga variety, but its seedlings seem to be equally hardy and well rooted.

The Haguenau pine is thus described by M. de Vilmorin; we quote from Dr. J. Croumbie Brown's translation:—

"The chief characteristic and the principal defect of the Haguenau pine consist in excess of vigour, and, above all, of a vigour ill distributed, which is often carried into the branches, to the detriment of the trunk. It is in this that it differs essentially from the true Riga pines. Its trunk is in general much less vertical and less regular, often crooked, warped, or abruptly falling off in size, in consequence of enormous overgrown branches, which grow out to a great distance and destroy all regularity in the tree. In one variety which is often met with, the tree is more compact, and the general habit more regular, but the crowns, much too strong, transform the summit into a pyramid excessively dense and bushy, in the middle of which the trunk is almost lost. On the other hand, the reddish colour of the bark is less uniform and less decided than in the good lots of the Riga pine; it commences generally one or two yards higher; pretty often, indeed, the bark throughout the whole body of the tree is grey, or mixed with grey, rather than reddish. That at the base of the trunk is more brown, more thick-zoned, and more full of rents.

"Truth requires it should be stated that there are to be found in the mass of the Haguenaus some individual trees which constitute an exception to the rest, being quite regular in trunk and in crown, with a bark fairly red, and retaining at the same time the superiority of vigour belonging to the race."

When, as is generally the case, the trees in a plantation are of a mixed character, due to mixtures in the seed from which they were raised, it is important to look very narrowly to the shape and habit of each tree in the work of thinning, so as to take out the worst varieties of individuals and leave the best. Also, when the forester collects his own seed, it is indispensable to select it from the straightest and best trees in full vigour, neither too old nor too young.

The pines of Geneva, the Ardêche, Briançon, etc., are recognised as inferior to the German variety, which is commonest on the Continent; if any foreign seed is imported into the United Kingdom, it is probably almost all of the latter sort.

Above all, the superiority of the Riga variety is sufficiently demonstrated to be worthy of the best attention of the forester, who cannot be too particular in ascertaining the origin, and consequently the quality, of the plants or seed he employs.

It may further be mentioned, to illustrate the very wide disparity prevailing among the types of *Pinus sylvestris*, that the Baron de Morogues, of Orléans, who classes the leading varieties of *P. sylvestris* as distinct species, found among the pines of Savoy alone fourteen sub-varieties unmentioned by botanists. These he classed as follows, either from their general appearance, from peculiarities in their leaves, or the scale of their cones, or from their local names:—

Pinus sylvestris ovata.
,, aduncа.
,, nasus.
,, umbilicus.
,, recta.
,, Macotii.
,, aeneus.

Pinus sylvestris persona.
,, arola.
,, unca.
,, oblongo conica.
,, herniacea.
,, erecta.
,, aculeata.

THE PINASTER, MARITIME OR CLUSTER PINE.

(*Pinus pinaster*, Soland ; *Pinus maritima*, Lamarck.)

This tree is a native of the shores of the Mediterranean. As its name implies, it thrives better than most other pines in places adjoining the sea, and it has rendered invaluable service by fixing the drifting sands of the Downs of Gascony,[1] where the surface redeemed from the encroachments of the sea has long borne a thriving forest, producing abundant returns from its resins, tar, turpentine, etc.,[2] which form the principal produce of this tree. Its wood is inferior in quality, but is employed for rough buildings; and it is said that successful experiments have been made with a view to its use when prepared with creosote or sulphate of copper for street-paving.

From the cheapness of its seed, and the ease with which it can be sown and reared, as well as from its remarkably rapid growth during the first years, this tree has unfortunately been too generally used for planting in districts further north than its proper habitat, particularly in Sologne, where at least three-quarters of the woods raised within the last fifty years were formed of *P. pinaster*. Certainly, as long as it lasted, it gave on the whole pretty good returns; but its constitution being weakly, and neither the climate nor the soil being quite suited to it, it was constantly subject to diseases, especially the *maladie ronde*, or round disease, already referred to. This species, moreover, is liable to destruction by frost. Thus in 1879-80, when the thermometer fell 20° Fahr. below zero, most of the Pinasters in Central France were destroyed, very young sowings covered by the snow being alone saved.

This tree cannot therefore be recommended for any purpose except that of utilising sand wastes, especially by the sea-shore, in a hot climate. To give a satisfactory growth, and to live out the natural term of its existence, it requires hot sun above and deep sand (however barren) below, to allow free penetration to its large tap-root, which is characteristic of the tree, the lateral roots being weak in proportion, and tending to emit in their turn miniature tap-roots instead of fibrous spreading ones, thus producing a powerful apparatus for fixing shifting sands.

The chief external features of this species are its long non-glaucous leaves, which measure from six to eight inches, two being in a sheath—they are rather twisted, and give a somewhat wavy and irregular appearance to its growth,—and its cones, which are the largest found among common forest pines. These cones are disposed in clusters round the bases of the secondary branches, whence originates the name of Cluster-pine. The bark is rough, dark, and thick, and altogether the aspect of the tree presents no charm, except the vigorous appearance of its growth in early youth and the agreeable odour it gives off in the evenings during its growing season. In warm climates it has sometimes two flows of sap during the year, one in spring and one in autumn, whence its very rapid growth. According to Dr. James Brown, the cluster pine can attain good size even in high latitudes, where the depth and lightness of the soil are in its favour. Thus some are known to exist on the island of Bute, and to measure sixty feet in height.

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[1] A very interesting account of this great work will be found in Dr. J. C. Brown's book, already quoted, chap. v.

[2] Dr. J. C. Brown's work also contains an account of the mode of extracting and preparing these substances. See chap. vi.

The method universally followed in France for propagating this pine is that of sowing *in situ*, the rearing and putting out of seedlings being troublesome and uncertain. The ground is ploughed either for a last cereal crop, or roughly for sowing the pine alone; the seed is then sown in lines or on small patches cleared by the mattock. In the former case, 3 lbs. per acre should be amply sufficient; and this can be procured at prices varying from 3d. to 5d. per lb.

It may be added that in warm climates, where it is desired to rear plantations of broad-leaved trees, the *P. pinaster* may be utilised as a nurse. It has sufficient cover to afford shelter, and helps to keep down weeds, though it cannot do this so completely as *P. sylvestris*, its roots and branches being less encroaching, and consequently it is not so liable as the latter to smother the plants it is intended to protect.

This pine is subject to all the insect and fungoid pests that attack *P. sylvestris*. Its particular enemy, however, and one which has destroyed many plantations in Central France, is the *maladie ronde*,[1] or round disease. The lighting of fires in the woods should be strictly prohibited, and charcoal especially should never be burned inside their limits. When, in spite of all precautions, the disease shows itself, the trees surrounding those affected, to a radius of thirty yards, or more, if the disease has been at work for any time, should be rooted up, and a ditch made round the part of the wood so treated, to prevent the passage of the fungi from the roots of the dying trees to those of the healthy ones. The disease has sometimes been stopped by simply cutting down the block in which it showed itself, the roots of the felled trees, when dried up, probably being unfitted for receiving and transmitting the fungus.

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[1] See *ante*, under the diseases of *Pinus sylvestris*.

There is a variety of *P. pinaster*, called that of Corte, which was found at Les Barres to be superior in growth and hardihood to the common Pinaster of Bordeaux. Unfortunately the plantations of it at that establishment were frozen in 1879, like those of the common type. Its seed is scarce and dear; but some might probably be procured for the purpose of an interesting experiment in Sylviculture from the Corsican Forest Administration, through the French Minister of Agriculture.

THE LARICIO PINE.

(*Pinus laricio*, Poiret; generally known as the Corsican Pine).[1]

This is a tree of very great size, being the noblest of European pines. Even when grown singly it forms a straight and regular cone, clothed with light branches from base to summit. It maintains up to a great height the cylindrical form of its stem, and in this way yields the maximum of useful timber.

Its branches, horizontal or slightly pendant, bear leaves from four to five inches long, sometimes diffuse, and generally twisted, two being in a sheath. Its cones, about two and a half inches in length, are generally borne in small groups, and contain greyish seeds, which are considerably larger than those of *P. sylvestris.*

The *Dictionnaire des Eaux et Forêts* (by Baudrillart, Paris, 1825), mentions that in the forests of Corsica some trees of this species attain the height of 170 feet! Travellers often admire their incomparable beauty, and it is to be noted that some individual trees contain from 1400 to 1800 cubic feet of timber, their stem measuring from thirteen to twenty feet in circumference, and being free of branches to a great height.

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[1] We prefer using the specific denomination, which includes at least one other variety, the Calabrian, as well as the Corsican. Many botanists regard several other trees as varieties of the Laricio, and the Catalogue of Les Barres, in particular, adheres to this classification.

The Calabrian variety of this pine is thus described in the Catalogue of Les Barres:—

"The Calabrian Laricio was introduced into France by M. de Vilmorin in 1819, 1820, and 1821. Specimens of it are now pretty common, but it has not taken in forest culture the place it deserves. It combines all the qualities of a first-class conifer, being a tree of the largest size, of active vegetation, with a straight, tall shaft, almost cylindrical, and with insignificant lateral branches. Its wood contains much resin, and is of very fair quality.

"It fructifies abundantly every year, and its seed, which is of good quality, sows itself naturally. It also comes up well in the nursery, but the young plants raised from it, like those of the Corsican variety, often fail when transplanted or put out.[1] Its seed is very expensive."

On visiting the estate of Les Barres, it may be observed that the Calabrian laricios are, of all the conifers, those which make the greatest bulk of timber in a given time.

Most of the young laricios planted in Sologne succumbed to the excessive frosts of 1879-80; but at Les Barres and elsewhere, the plantations of both varieties above mentioned, aged from thirty to fifty years, were not at all hurt. As it is highly improbable that such a calamity will recur for the next fifty or sixty years, during which this species can mature its sapwood, the misfortune need afford no ground for ceasing the cultivation of this first-class tree; especially as the Arctic weather which then desolated Central France can hardly be possible, either in southern and warmer countries, or in the climate of Great Britain and Ireland, where extremes of all sorts (except that of wet) are tempered by the close proximity of the Gulf Stream.

The laricio pine is not exacting on the score of soil, as it will grow in very poor sand with fair success. Being a tap-rooted tree, it will doubtless thrive best in deep sandy loam, but it is also said to grow well in fairly calcareous soil. On the other hand, it is, from its weak lateral roots and light cover, unfitted for struggling successfully against strong stiff heather in very acid ground. Being a southern species, it will succeed best with a southern exposure, and although a mountain tree in its native clime, Dr. Brown remarks that it cannot do well on high-lying exposed sites in cold climates.[1]

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[1] This difficulty is probably special to large plants. We have always succeeded by using two-year-old ones one year transplanted. When older they are apt to make long bare roots without fibres. It is very important to choose cloudy damp weather, without high wind, for planting.

Besides its rapid growth, the laricio is less liable than any other species of conifer to be devoured by the rabbit; and its straight growth and light cover make it an excellent nurse for broad-leaved species, particularly in flat land and under warm climates unfavourable to the growth of the larch.

The tall straight trunks of the laricio, alternating with American red, marsh, and scarlet oaks, red maples, or any other colour of broad-leaved tree, would make magnificent borders to forest avenues, roads, and rides, and vastly increase the pleasure afforded by our woodlands.

The seed of *Pinus laricio* is generally mixed with much refuse, so that the proportion that germinates is less than that of the seed of *P. sylvestris*. It comes up, however, as easily in the nursery, and the seedlings stand the heat of the sun rather better, providing the land be not too dry. Owing to the inferiority of its seed, it may be sown somewhat more thickly than that of *P. sylvestris*.

For planting it is best to employ seedlings two years of age and one year transplanted, as, from their tendency to make long roots without fibres, older seedlings, unless transplanted every year, do not succeed. In cool, cloudy weather, fine stout yearling plants, which have been thinly sown, and grown in narrow drills, may be planted out with success. These, however, are more liable to be attacked by rabbits than the former.

In planting it is always advisable to cut or break up the sod, and crumble the lower earth round the roots of the seedling.

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[1] We read, however, in *Forestry* for May 1884, p. 59, that it is found thriving at Blair-Athole, at an altitude of 700 feet.

Good yearling plants of the Corsican laricio are now to be had in Central France at 2s. 6d. per 1000, and two-year-old ones, one year transplanted, at 5s. or 5s. 6d. per 1000; the cost of planting will therefore be little, if at all, over that already calculated in the case of *Pinus sylvestris.*

If good seedlings be carefully put out, and if very bad soils, which should be reserved for *P. sylvestris*, be avoided, an interval of five feet should be sufficient for laricios, even although some failures are always to be expected. As the nature of the tree is to grow straight and tall, it can safely be planted at such wide intervals, and it will come away the stouter by being thus set. If a profitable market for first thinnings can be got, the seedlings may be put out more closely.

As a nurse for broad-leaved plants, laricios may be placed from six to nine feet apart, according to the thickness of the former, which should never have such a start of the pines as to be able to shade them.

As at six feet apart 1210 plants are required per acre, at seven feet 889, at eight feet 680, and at nine feet 537, the expense involved may be readily calculated, necessary deduction for roads being made.

This pine may be advantageously planted in autumn, in dry soils. In heavy land, liable to split up under the action of frost, it is necessary to defer the work until spring, and favourable moist weather must be chosen.

The wood of the laricio is more resinous than that of *Pinus sylvestris*, though rather less strong and elastic. It is employed in Corsica for carpenters' and joiners' work, and for making masts for small craft; it is also used in the dockyards of Toulon for ship spars and planking.

From the Calabrian laricio came the famous pitch celebrated in the verse of Virgil and Horace, and its wood forms the torches that are burned by the inhabitants of the Sila Hills, instead of candles, to light up their houses.

The laricio is exposed, like *P. sylvestris*, to the attacks of *Hylesinus*, and of the elephant beetle. It has not been observed to be attacked by any other enemy in Sologne; but it is probably subject, like *P. sylvestris*, to the rust disease (*Œcidium pini*).

With regard to thinning, it is to be noted that since this species seldom shows a bushy habit, this can be done with confidence when necessary.

THE BLACK AUSTRIAN PINE.

(*Pinus nigra*, Linn.; *Pinus Austriaca*, *Pinus laricio Austrica*, Endlicher.)

This tree, nearly related to the laricio, of which it is often classed as a constant variety, still differs from it in several important points. It is more sturdy and thick-set, and its branches are stouter, more numerous, and closer. Its leaves are darker, and stiff, and straight, instead of twisting; the scales of its buds and the sheaths of its leaves are of a sombre grey, giving it the dark appearance from which it derives its common name. Its roots partake of its stouter general habit, and the lateral ones are more numerous and fibrous than those of the laricio.

The Austrian pine, specially valuable for utilising dry calcareous soils, covers plains of chalky gravel in Lower Austria, where hardly anything else will grow. It has also been successfully planted in the barren chalky plains of Champagne Pouilleuse, stretching between Chalons and Troyes. In Sologne, where most of the soil is practically devoid of lime, it has been found less hardy than *Pinus sylvestris*, and it does not take well to such soils, especially when very dry, not being able to sustain the struggle for life with stiff-binding heather, which generally develops in dry acid land. Its growth is pretty free, but not so rapid as that of *P. sylvestris* and *P. laricio*. Under the moister climate of Great Britain it is considered hardier, and it is well fitted for planting in the neighbourhood of the sea, doing even better than *P. pinaster* on the shores of the Channel. It is said also to stand high altitudes and exposure better than larch or Scots pine; but for general hardihood the latter is to be preferred.

The Austrian pine is raised from seed as easily as *P. sylvestris*. Its plants are quite hardy, and take readily, but remain almost stationary for a year or two after being put out. Where sowing *in situ* is practicable, whether in lines or in patches, it is preferable to planting. The cost of sowing or planting will be much the same as in the case of *P. sylvestris*, and the same system can be followed, its seedlings being equally hardy. Intervals of five feet should be allowed in planting, as its branches are stout, and soon fill up the space between the stems. Although it does not show, when single, the straight growth of the laricio, it has not, when grown in blocks, much tendency to straggle. Mr. Hœss[1] remarks that the wood of the Austrian pine is yellowish white towards the circumference, and of a rusty yellow at the heart. It is the most rich of all European trees in resinous sap, a plantation which he mentions having partly a northern and partly a southern exposure, yielding ten pounds per tree per annum. It is to be noted that trees grown singly will yield more.

At Cheverny, Loir et Cher, the seat of the late well-known savant, the Marquis de Vibraye, fine plantations of this tree are to be seen on slightly calcareous soil, and fagots cut from these may, it is said, be burned perfectly green, on account of the abundance of resin which they contain.

According to Mr. Hœss, the wood of this pine, harder and tougher (in his climate) than that of *P. sylvestris*, is employed for the same uses; it is particularly prized for building under water, and for this purpose it is used as much as larch.

"From youth to maturity the Austrian pine has all the qualities required to make one of our finest conifers. The symmetry of its proportions, its imposing habit, the length and thickness of its leaves, which grow close against each other, its massive column of verdure, the agreeable and healthy odour it diffuses, its majestic top, and its bright cones, form a harmonious whole, which strikes the observer by its regularity."

Generally speaking, it is certain that this pine, when grown in suitable soils, can attain fine development, and is well worth cultivating, although it is not so universally hardy and useful as *P. sylvestris*; but, owing to its slow growth, it should be planted alone, and not mixed with any species of pines which would tend to smother it.

Its diseases are the same as those of the Scots pine already described.

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[1] *Monograph of the Austrian Pine.* Vienna, 1831.

THE MONTPELLIER PINE.

(*Pinus monspessulana* or *P. Salzmannii;* Fr. *Pin laricio de St. Guilhem.*)

This tree seems to be a variety of the Austrian, having exactly the same growth, form, and proportions, and organs of the same shape and dimensions. Like the latter, it is classed as a laricio by most French authorities; but the two trees are practically very distinct from the Corsican and the Calabrian pines, in their dimensions, habit, rapidity of growth, foliage, and in the character of their roots. It is also to be remarked that, although the natural habitat of these trees is nearly as far south as that of laricio, they have resisted the severe frosts of 1879, to which the latter, in its younger stages, succumbed. The only point which distinguishes the Montpellier from the Austrian pine in its youth is the hue of its foliage, leaf-sheaths, and bark, which is light and cheerful, instead of being dark. As an ornamental tree, it promises to be superior to the latter, and it is equally hardy. When the two are planted together, at pretty wide distances, so that they may not stifle each other, the contrast is very agreeable.

The seed of this pine is scarce, and often difficult to procure, the seasons in which it is yielded being irregular. Seedlings, however, can be procured from nurserymen in Central France at rates sufficiently reasonable to allow of planting for ornamental purposes; but as yet the tree is not sufficiently common for general forest work, although it may be used as a supplement for the black Austrian, to which it is so closely allied. The treatment and soil which are suitable to the Austrian should be also perfectly adapted for this variety; only, on account of the comparative scarcity of the species, more care should be taken in planting it. It is worthy of propagation, both from its hardiness and its fine ornamental qualities.

LORD WEYMOUTH'S PINE, AMERICAN WHITE PINE.

(*Pinus strobus.*)

This is the most important of all American pines, furnishing not only most of the timber used in the United States and

Canada, but also most of that imported from these countries into Europe. In the northern and eastern portions of North America it occupies enormous tracts of ground, generally in company with deciduous trees of various sorts. Yet the supply of this timber is steadily and rapidly diminishing, partly owing to reckless and improvident felling carried on under the impetus of speculation.

The Weymouth pine is the most elegant of all the species usually grown. It is easily distinguished from the rest by its grey bark, which is smooth and shining up to the age of fifteen years, after which it cracks and becomes somewhat rugged; by its leaves, five of which occur in a sheath, and which are fine, flexible, and of a glaucous hue; and by the graceful lightness of its branches. It is perfectly hardy with regard to the severest frosts, either of winter or spring; it grows straight, either singly or in plantations, and quite as rapidly as the Scots pine, if not more so.

In its natural habitat it attains a gigantic size. It has been known to measure 200 feet in height, and trees 150 feet high are not uncommon, or at least were not before the destruction of American forests became so reckless. In Europe its proportions are smaller, but it often rises to a height of seventy feet, with comparatively stout girth.

The Weymouth pine has certain defects associated with its light but elegant form. Its top-shoot is slender, and easily broken by birds or squirrels, so that although its natural tendency is to grow straight even where planted singly, it is sometimes found double-headed from the result of an accident. Its smooth and tender bark is sensitive and easily wounded, so that it is often seen marked by small trains of sap shed from abrasions. Its constitution however being vigorous, and its growth rapid, it very soon recovers from such misfortunes; and it may be considered, on the whole, the finest ornamental pine commonly grown.

For purposes of general forest usefulness it is less valued. It has often been recommended for planting marshy land, but for this purpose it does not succeed better than the Scots pine, which furnishes better timber. On the Continent, as in the United Kingdom, its wood has never yet ripened sufficiently to be of any value.

In parks and ornamental plantations it can be mixed with coppice-wood with fine effect. When widely planted, its light cover can have no bad influence on broad-leaved species.

This tree attains its best development in land which is at the same time cool, dry, and deep; it is in the valleys of rivers, in sand mixed with humus, that it acquires all its beauty; but it comes away admirably, at least during its youth, in dry sand of a certain depth.

As sowing it in the nursery requires special care, it will generally be found best to buy plants from a good nurseryman. In Central France, two-year-old plants are worth 6s. or 7s. per 1000; and three-year-old ones, 10s. They can be planted in little pits filled with mould, so as to give them a good start, in order that they may soon become ornamental.

OTHER HARDY CONIFERS OF INTEREST.

It may now be interesting to enumerate the Coniferæ which have been successfully grown on a smaller scale than the common pines in Sologne, for the purposes either of pure ornament, or of propagation of their species for forest planting, by means of their seed, which at present is too scarce and expensive for work on a large scale. The fact that these trees succeed in Sologne may be taken as proof of their hardihood.

In planting such sorts it is of course advisable to choose soil as cool and deep as possible, and to use more than ordinary care in doing the work. The best situation, as a rule, for ornamental trees, will be one where they are sheltered, without being shaded, by other trees, which should be sufficiently distant to prevent their roots from coming into competition with those of the young plants.

Up to the age of three years, plants of most conifers may be put down with a wide, rounded spade. When older, they require pits, with the earth of which it is advisable to mix light mould, such as that obtained in cleaning ditches; but nitrogenous manure must be avoided.

During the first years a little cleaning of the soil does the plants a great deal of good; but, on the other hand, the cleaner and looser the soil is, the more rabbits are tempted to visit it. When this is to be feared, the plants may be surrounded either by bits of wire-netting, eighteen inches high, or by a little pile of furze heaped round them, which it is necessary to renew at the beginning of each winter. The furze must be green, because when it dries up and settles down rabbits walk over it. It should be tied round the plant when the latter is strong enough to bear it. When it is properly applied, and has decomposed, it forms an excellent compost for the soil, being rich both in organic and mineral constituents.

When it is desired to plant a young tree of some size, not recently transplanted, it is prudent to prepare it a year beforehand, by trenching round it, so as to cut its roots short, and oblige them to emit fibres, and also to insure the lifting of a good ball of earth. In putting out the tree, care should be taken to give it the same exposure as before, for if the side formerly looking to the south were turned to the north, its branches might suffer from unaccustomed cold. This precaution is probably as old as tree-planting, and is noticed by Virgil in his *Georgics.*

Ornamental trees should not be planted too close, nor left too thick; on the contrary, they should be placed at wide intervals, and the intervening spaces should be filled up with commoner sorts as nurses, which should be gradually thinned out as the permanent occupants of the soil continue to grow.

Trees apt to make early, tender growth, and therefore to suffer from spring frosts, should be planted without direct cover, so as to be sheltered from the rays of the rising sun, to which the mischief done is commonly due.

It is remarkable that, contrary to what might be expected, the species indigenous to cold climates and exposed mountain sites are often most liable to suffer from spring frosts. The reason is, that by being transferred to a warmer climate and more sheltered situation, their growth is stimulated, and their shoots have a tendency to come out earlier in the season than in their natural habitat—

> "And then there comes a frost, a killing frost,
> And when they think, good easy *trees*, full surely
> Their vigour is a-ripening, nips their shoot."

The Fir tribe, in their first stages, are particularly liable to this accident. They can almost all stand the severest winter frosts, and one may often see the shoots of young firs that have resisted a temperature of even *minus* 20° Fahr., as in 1879, completely "frozen back" in spring.

The *Cupressineæ*, which make spring growth later, are not thus affected in spring, though some may suffer in autumn from growing on late.

The principal attraction of plantations of ornamental Coniferæ is due to the great variety in habit and shades of colour of the species. They should therefore be judiciously associated, so that the growth of each in spring should come to a different stage at the same time, and show diversity in this respect as well as in their permanent colour and form.

TREES KNOWN TO SUCCEED IN SOLOGNE.

(1.) The Larch, in a flat country, and under a hot summer sun, cannot be expected to attain its best development, nor to produce its best timber, so it is not used for general forest work. It may however be put down to form borders to plantation roads, where it offers a delightful contrast to the dark sturdy pines, and comes away remarkably fast, as in such situations the ground is at once well drained and amply shaded.

Larch seems to succeed much better on heath-covered soil than might be expected from its deciduous, light cover. According to Dr. Weber's analyses, it is, after pines, the least exacting of all trees as regards mineral constituents, and it absorbs even less lime than pines, whence, probably, its suitability to heath-covered ground. From its light pyramidal shape and moderate cover, it is most valuable in cold climates as a nurse to the broad-leaved species.

Up to the age of two years, when its growth should be strong, it can be planted on a large scale as easily as the Scots pine, and with very little more expense. It is more difficult to rear in the nursery from seed, which requires to be lightly covered, as the kernel is very small. When the seedlings are above ground, they require to be sheltered, by means of light hurdles of broom or heath, from frost in spring and autumn, and from the sun in summer. Unless, therefore, the forester enjoys a climate moist enough to insure safety from these dangers, and unless work is to be carried out on a very large scale, he will do better to buy young plants than to rear from seed.

(2.) The Spruce Fir (*Abies excelsa;* according to continental botanists *Picea excelsa*) grows well in Sologne as a young tree. Some specimens of it, from fifteen to twenty years old, make over three feet of annual growth, on very poor sandy soil, but it prefers a good deep loam. In the valleys of rivers, and in pleasure parks, it attains good proportions.

It never suffers from frost in any season, or at any stage of its growth, except when its young plants in the nursery are tempted by a mild winter to make too precocious growth in spring.

Spruce grows well in drained bogs; it makes an excellent nurse, keeping the ground clean with its cover, while its tapering top does not encroach on other trees. Finally, it is well fitted for avenues, from its regular and graceful habit. Dr. Weber has found that it absorbs more lime and silicic acid than pines and other firs. In Sologne it gets abundance of the latter, but is obliged to content itself with an infinitesimal quantity of lime.

In the nursery it comes up well from seed, but requires shading in summer under the French climate, all firs being shade-loving, while all pines are sun-loving, plants.[1]

Seedlings of spruce can be transplanted at all ages with remarkable facility, when proper care is exercised, and although planting out may retard their growth more or less, according to their size, hardly any will die off.

(3.) The Douglas Fir (*Abies Douglasii*) is a connecting link between the Tsugas, or drooping firs, like *T. Canadensis* and *T. Albertiana*, and the upright-growing spruces. It attains gigantic size in its native habitat in the north-west of North America.

Its growth is fully as vigorous as that of the spruce, that of its lateral branches perhaps stronger. Its leaves are lighter, and its general aspect more cheerful. It is equally hardy, transplants with great facility, and seems, once planted out, never to be affected by spring frosts, as it shoots rather late in the season. Young plants in the nursery, however, require a little shelter in spring and summer.

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[1] Hence the terms "Pine" and "Fir" should not be confounded.

Its top-shoot, long and slender, is very apt to get broken by large birds when perching on it. Even for ornamental purposes, it should be planted in clumps or lines, or mixed with other conifers, rather than singly.

As a young tree, it comes away rapidly and vigorously in the most arid soils of Sologne, while in better soils it is still more vigorous. In France, its full value for forest work not being generally known, it is not very common; but in the United Kingdom it may be procured on very reasonable terms. It can be raised from seed under the same conditions as the Scots pine, but it requires, in warm summers, to be sheltered from the sun, like all other firs.

The timber of the Douglas fir, in its native clime, is excellent. The light elegant furniture called pitch pine is generally made from this wood, though the name given to it properly belongs to *Pinus rigida.*

(4.) The Silver Fir (*Picea* or *Abies pectinata,* so named from its distichous leaves, set like the teeth of a comb) is not adapted for extreme climates or poor soils, where, up to the age of eight or ten years, its shoots get frozen regularly every spring. This keeps it low, and exposes it to the danger of being constantly eaten down by rabbits. In Eastern France it suffered from the extreme winter frosts of 1879, its sensibility in this respect being due, according to some authorities, to an insufficiency of silicic acid in its leaves. It is also more exacting than spruce as to the physical qualities of the soil. In this it requires coolness and good depth.

(5.) Nordmann's Silver Fir (*P.* or *A. Nordmanniana*) is supposed to be an improvement on *A. pectinata,* being less subject to suffer from frost, while it is certainly highly ornamental. It is a native of the Caucasus, and is easily distinguished from the common silver fir by its leaves, which are longer and more numerous, more thickly set on the branches, and which give it a vigorous, and at the same time graceful, appearance. It should be planted in deep cool land.

(6.) The Balm of Gilead Silver Fir (*P.* or *A. balsamea*) is a light and elegant diminutive of *A. pectinata,* but it is perfectly hardy, and is a delightful little ornamental tree. It does well on the poorest soils, and very seldom suffers from spring frosts. The agreeable smell and the cheerful glaucous hues of its leaves, the bright colours of its red male flowers, and the fine purple cones which develop later in the season, combine to make it a desirable plant. As it does not last very long it may be advisable not to depend on it for permanent ornamental effect, but to have some other tree behind it to take its place in the landscape when required.

Seedlings of this species can easily be procured from nurserymen, in the limited numbers required for ornamental purposes. They transplant with perfect facility and success.

(7.) The Wellingtonia (*Wellingtonia*, *Washingtonia*, or *Sequoia gigantea*) is well known to be a native of a very limited region in California. Its gigantic size and general characteristics are familiar to all, and it is an ornamental tree of the highest practical value.

On the very worst arid soils it makes extremely rapid growth, and seems to flourish better than on stiff heavy land. In Central France, specimens that have been planted for nine years measure over a foot in diameter at their bases, and although the tree tapers considerably, its proportions are beautifully harmonious.

Although severe frosts destroy young trees, they are less sensitive in this respect when they have attained a greater age and possess more lignified tissue.

Nurserymen generally raise this species from slips, but seedlings come up fairly in the nursery, and generally transplanted plants take well.

(8.) The Californian Redwood, generally called *S. sempervirens*, or preferably, *S. taxifolia*, from its distichous leaves,[1] is of too immoderate growth to make an independent forest tree in extreme climates. Its shoot, often five or six feet long, like that of the *Ailanthus*, has not time to ripen before the arrival of autumn frosts, which nip it, so that it is generally found to be stag-headed.

It is peculiar inasmuch as it forms coppice when cut over, like deciduous trees, and, according to M. C. de Kirwan,[2] it grows more vigorously under moderate shade (which protects it from frost) than any other conifer; it has also the faculty of emitting suckers from its lateral roots—qualities which render it valuable for filling up vacant spaces in plantations. The Marquis de Vibraye, according to M. de Kirwan, described a plantation, made by him at Cheverny, as forming a regular coppice-wood of *Sequoia taxifolia*, under high trees of the same species.

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[1] *Sequoia taxifolia* (yew-leaved) would be a better name, as it is now no longer classed as *Taxodium*, and *sempervirens* is no distinction from other conifers.

[2] *Les Conifères*, pp. 53, 54. Paris, Rothschild, 1868.

The immense size attained by this tree, second only to that of the Wellingtonia, and the superior quality of its timber, would make it a most desirable forest tree, if, when grown in cold and sheltered situations, it could be protected from frost.

Most of those planted in Central France were destroyed by the frost of 1879, but in the Botanic Garden of Tours a fine specimen withstood the very low temperature at that time.

(9.) *Taxodium distichum*, the Louisianian or Bald Cypress, is a first-class ornamental, and in many cases a useful, tree. It is, besides the larch, the only well-known conifer that loses its leaves in winter. These are elegant in shape, and of a pale delicate green colour, turning to a reddish brown in autumn, and remaining for a long time on the branches before their fall, so that its aspect is always striking.

Though a native of southern climates, it withstands winter frosts well. It is essentially a water-loving tree. In Louisiana and the neighbouring States it covers vast marshes and river-banks, where its trunk is inundated during several months of the year, sometimes to the height of ten feet, yet it grows vigorously under these conditions!

The peculiar exostoses or protuberances that rise from its roots, too well known to the unfortunate travellers who have to cross those swamps under the name of "Cypress knees," would seem to be a provision of nature for giving the roots, where the soil is inundated, the necessary communication with the oxygen of the air, for in land with a dry surface, even where *Taxodium* grows very vigorously, these extraordinary developments do not appear.

This tree, in addition to its value for ornamental purposes, is highly recommended for fixing the banks of rivers, by means of its powerful root system, and in Sologne it has been successfully planted for this object.

When sown in cool, moist nursery ground, it comes up very rapidly, but it requires early transplanting on account of its long tap-root. Special protection is necessary against rabbits, which have a marked propensity for devouring it.

Its wood, in Louisiana, is said to possess remarkable strength and elasticity, and to stand alternations of temperature and of moisture extremely well. In the beginning of this century the houses of New Orleans were nearly all built of it. It is also utilised for water conduits under ground; and finally, it is said that canoes or *pirogues,* more than thirty feet long by six wide, are hollowed out of its trunk.

TREES WHICH PROMISE FAIRLY.

With *Taxodium* we terminate the list of hardy trees we can confidently recommend for planting in poor soils for forest or ornamental culture. We shall now mention a few species which we consider likely to succeed, and whose cultivation would be interesting to the forester and worthy his attention:—

A.—*Pines with five leaves in a sheath.*

(1.) *Pinus* (*Strobus*) *excelsa* (*Nepalensis*)—or the Lofty Himalayan, Nepaul, or Weeping Pine—resembles the Weymouth pine exactly in all respects, except in the length of its leaves. These are about twice as long as those of the Weymouth pine, and, being too fine to remain stiff, they hang gracefully, so as to justify the name of " Weeping Pine," which has been applied to the tree. It has the same elegance and slenderness, the same rapidity of growth and hardihood, as the Weymouth species.

(2.) *Pinus Lambertiana*—Lambert's, or the Great Sugar Pine —is a gigantic Californian tree, sometimes 200 feet in height, with large leaves, which are stiffer than those of *Pinus strobus.* It bears enormous cones. It requires to be planted in clumps to grow perfectly straight. It is hardy, and easy to raise in the nursery.

B.—*Pines with three leaves in a sheath.*

(1.) *Pinus insignis*—or the Remarkable Pine—owes its name to its particularly bright grass-green colour. Besides its very rapid growth, its seedlings have the quality, though tap-rooted, of transplanting well, and resisting spring frosts; it therefore seems to be well worth cultivating as an ornamental pine, its shade of colour contrasting most effectively with that of other conifers.

(2.) *Pinus Sabiniana*—Sabine's Pine—is a fine Californian species, distinguished by the beauty and symmetry of its growth. It has very long leaves, and cones of a size inferior only to those of *P. Lambertiana.* Its seeds are as large as good-sized kidney beans, and come up well in the nursery, but the seedlings do not transplant easily.

(3.) *Pinus Coulteri*—Coulter's Pine—is distinguished by its leaves, which are thicker and heavier than those of any other species. Loudon remarks on the great beauty and perfect hardihood of these two pines, which, like *P. insignis,* are Californian.

The seed of *P. Coulteri* is very large, and comes up well in the nursery.

(4.) *Pinus ponderosa*—the Heavy-Wooded Pine of Western North America—has the reputation of being a good timber tree, and its seedlings are tolerably hardy in the nursery. It should, according to Dr. Brown, be cultivated on light gravelly soil, as on rich land its shoots grow too late in autumn, and are nipped by frosts.

Pinus rigida—the Stiff-leaved, Swamp, or Pitch Pine of Eastern North America—is a second-rate tree, but hardy, and of rapid growth. It has been supplied to State foresters in Corsica for planting marshy land.

C.—*Pines with two leaves in a sheath.*

(1.) Among two-leaved pines, *Pinus resinosa* or *rubra*—the Resinous or Red Pine—occurs in Canada, Nova Scotia, and the Northern United States, and furnishes, next to the Weymouth or white pine, most of the timber used and exported. Its stem is very cylindrical, and is capable of furnishing a large quantity of useful wood. It is said to prefer light sandy soils, and to resemble the laricio in general appearance.

Among the Firs, perhaps the hardiest ornamental tree is *Picea* or *Abies pinsapo*—the Spanish or Pinsapo Silver Fir. Its branches, bearing glaucous and remarkably stiff leaves, form a regular compact cone of fine colour; and as its shoots start late, they do not seem sensitive to spring frosts. It comes away freely in very poor dry soil.

There are many other ornamental firs, such as *Picea nobilis, P. grandis, P. Cephalonica,* and *P. amabilis,* among silver firs; *Picea morinda, P. orientalis, P. Menziesii* or *Sitchensis,* among spruce firs; and *P. Canadensis,* or Hemlock Spruce, or Tsuga.

These may all be reared in deep soil, with a fair amount of moisture, if they are sheltered as much as possible from the effects of frost. When they grow well, their ornamental effect is magnificent, being far superior to that of pines, but they are more delicate, and require better soil.

Cedars are too well known to require any description here. That of Mount Atlas, *Cedrus Atlantica,* is lighter in hue, and of faster and more slender growth, than its compeer of Lebanon. In Central France all the young plants of this genus were frozen in 1879, and all the Deodars, or Indian Cedars, of every age; but this does not seem to have been the case in other climates.

Cedars are difficult to transplant, and require good deep soil. The rabbit has a particular fondness for the young trees, so that special care is necessary for their protection.

Among the Cupressineæ, *Cupressus Lawsoniana*—Lawson's Cypress,—and *Thuja gigantea,* as well as Lobb's Thuja (*T. Lobbii* or *Menziesii*) are now recognised as valuable forest species. *Cupressus Lawsoniana,* variety *erecta viridis,* has the quality of keeping its deep green shade of colour unaltered throughout the winter; we have a specimen which flourishes in poor dry soil, and in spite of severe damage done to it by rabbits in its early stages.

Among *Junipers,* the most important is undoubtedly the Virginian—improperly called the Red Cedar,—*Juniperus Virginiana.* At maturity it yields wood of an excellent quality and fine grain, which is chiefly used for the manufacture of pencils; and before it becomes a tree it makes, *en attendant*, a handsome little shrub. Its seed takes very long to come up, and should be stratified before sowing.

There are some very graceful plants obtained by nurserymen from grafts on *J. Virginiana*, such as *J. Schottii*, *J. Chamberlainii*, *J. Gossinthiana*, *J. odorans*, and others.

There are, besides, the Chinese Juniper, *J. Sinensis*, the male of which bears bright yellow flowers in autumn; *J. rigida*, which has stiff prickly leaves, but graceful habit of growth; *J. prostrata* and *J. tripartita*, of curious creeping habit, their top and lateral shoots all falling to, and running along, the ground. The common species, *J. communis*, is as ornamental as any. It has a peculiar sugar-loaf form, and a deep shade of green, which remains fresh throughout winter.

Most of these attain little more than the size of shrubs, or third-rate trees, and their growth is not very rapid, but they are hardy, graceful, vigorous in poor soils, and are not liable to be damaged by frosts.

Retinosporas have much the same qualities. *R. obtusa* is the "sun-tree" of Japan, where it attains the height of from 70 to 100 feet; the others are mostly of small size. They prefer porous heath-covered soil to any other.

The following is a list[1] of new trees which the Prussian Government is introducing, as useful additions, into the State forests; it comprises a good many of the species above enumerated:—

Abies Douglasii	from	N. America,	West.
,, Menziesii v. Sitchensis	,,	Japan (?), N. America,	,,
,, or Picea Nordmanniana	,,	Caucasus.	
Pinus rigida	,,	North America	East.
,, ponderosa	,,	,,	West.
,, Jeffreyi	,,		,,
,, laricio	,,	Southern Europe.	
Cupressus Lawsoniana	,,	North America,	West.
Juniperus Virginiana	,,	,,	East.
Thuja gigantea	,,	,,	West.
Juglans nigra (Black Walnut)	,,	,,	East.
Carya alba (White Hickory)	,,	,,	,,
,, amara (Bitter-Nut do.)	,,	,,	,,

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[1] Communicated to the British Embassy, and thence transmitted to Dr. Lyons, M.P., March 1884.

Carya aquatica	from North America,	East.
,, tomentosa (Woolly Hickory)	,, ,,	,,
,, porcina (Pignut do.) . .	,, ,,	,,
Quercus rubra (Red Oak) . .	,, ,,	,,
,, negundo (Ash-leaved Maple)	,, ,,	West.
,, saccharinum (Sugar do.) .	,, ,,	,,
,, dasycarpum (Hairy-fruited do.)	,, ,,	,,
Populus monolifera (Necklace-bearing Poplar.)		,,

Also some Japanese Conifers.

Ornamental Coniferæ, while very interesting, are really useful in breaking the monotony which always results when a single species of pine is planted, and nothing in horticulture is more agreeable than their cultivation.

Moreover, hardy pines are of extreme value in the utilisation of waste land; and the foregoing notes may help to guide any intending planters in this work, encourage them to proceed with it, and guard them against useless expenditure in the making of plantations, which, with moderate outlay, permanently increase the value of the land and the resources of the country.

VIII.

NOTES ON THE VARIOUS METHODS OF PRODUCING AND HARVESTING CINCHONA BARK.

By J. Alexander, *Kirklees Estate, Ceylon.*

It is unnecessary to describe the early history of Cinchona, and the introduction of the tree into India and Ceylon, as this Essay is confined to recording the results of the writer's practical personal experience during the last twelve years. Many useful hints have been derived from brother-planters and cinchona cultivators in India and Java.

Ceylon is peculiarly adapted for the growth of cinchona, and its cultivation has proved a highly remunerative undertaking for many, especially during the few years of bad coffee crops. Samples of Ceylon bark were first sent home for analysis in 1866; the bark attracted attention in the London market in 1868, and the prices realised soon after induced a brisk demand for plants in the island.

SPECIES OF CINCHONA.

Without entering into a complete history or botanical description of the several species of cinchona, those commonly grown in the East may be briefly described.

Cinchona succirubra (*genuine red bark*).—This species is most largely grown; it is very hardy, and becomes a fine tree, and it grows in situations from 2000 to 5000 feet above sea-level. So far it has been the most profitable, and it succeeds over a larger area than any other cinchona yet grown. Some very fine trees about twenty years old, over fifty feet in height, and with stem girth of forty inches near the base, are growing on Kirklees estate. The greatest quantity of dry bark from one tree, *C. succirubra*, when cut down, was 90 lbs.

C. robusta (*hybrid*), so named by Dr. Trimen, comes between *C. succirubra* and *C. officinalis.* The trees are greatly esteemed, since they are hardy, grow quickly to a large size, and afford a bark which gives very good analyses. Elevation for cultivation from 2000 to 5000 feet.

C. officinalis (*crown bark*) is grown at heights of from 4000 to 7000 feet. It is found to be specially suited to the dry Eastern hill districts of Ceylon, where some very fine plantations are to be seen. Within a mile of the mountain Sanitarium, "Newera Elliya," is Lover's Leaf estate of 100 acres, at an elevation of 6500 feet. It is considered the finest *officinalis* plantation in the East.

C. officinalis, var. *Condaminea* (*rusty crown bark*), a large-leaved variety which grows to a good-sized tree, and flourishes at lower elevations than the others. The bark is nearly of equal value to the preceding variety.

C. officinalis, var. *crispa* (*fine crown bark*), a small shrubby tree with very fragrant and pretty-looking bark, which brings a high price in the market. It thrives best at a high elevation.

C. Calisaya, and its varieties, *vera*, *Javanica*, *Josephiana*, etc. (*yellow barks*).—This species of cinchona has not succeeded well in Ceylon. The bark is proved by analysis to be poor in alkaloids, and it is consequently of little value. Possibly some of the new varieties now being introduced may succeed better, but hitherto great difficulty has been experienced in growing a tree; it always inclines to form a low bush, and is specially liable to die out. It grows at elevations of from 2000 to 5000 feet.

C. Ledgeriana, Moens, Java (*Ledger bark, Queen of Cinchonas*).—This species of cinchona claims its origin from the seed obtained by Mr. Ledger in 1865. It is the most valuable bark tree yet known, and has found a congenial home in many of our sheltered valleys. It has a thick bark, very rich in quinine, and by drying it only loses one-third in weight, compared with two-thirds in the other cinchonas. There are several flourishing plantations in Ceylon ranging from 2000 to 5000 feet. Java leads in the cultivation of *Ledgeriana*, but in comparing analyses, the results obtained in Ceylon are seen to be better.

C. micrantha (*grey bark*).—This is a large free-growing tree, which is rather unprofitable to cultivate, as the bark contains a very small percentage of quinine.

C. Pahudiana grows at high elevations, and is not worth cultivating, as the bark is not generally rich in alkaloids.

HARVESTING THE BARK.

Pruning and Lopping.—This operation is necessary to a great extent where cinchonas are grown in vacancies among the coffee, and where consequently the lower branches require to be removed as soon as they begin to shade the coffee-trees. The style of working carried out by many planters, where the trees are denuded of all their branches, is not to be recommended. I consider such pruning most injurious to the trees, for by curtailing their elaborative and transpiring powers the root-action receives a severe check. Quinine and other alkaloids are first formed in the leaves by the action of light and air on the juices, and while the leaves are performing their usual office of elaborating the sap or juices of the plant. Quinine is most abundant in the cellular tissue of the bark, where there is also a process of waste, caused by the action of light and air on the bark. With *C. succirubra* and other strong-growing cinchonas little pruning is necessary until about the fourth year. *C. officinalis* and *Calisaya*, varieties which are inclined to grow more into bushes, require considerable attention in the way of pruning before a tree is formed. The twigs and branches should be barked as they are lopped off, and the simplest and most effectual method of doing this is by means of two round sticks, about eighteen inches long, driven into the ground close together. One hand rests on the top of the pegs and presses them together, while the branch, being fixed between, is pulled through with the other hand. A man can dress the branches and remove 50 lbs. of wet bark per day in this manner.

Shaving.—We have to thank Mr. Moens of Java for this system of harvesting bark; it is strange that it was not sooner thought of, since it is the cheapest and most practical. A thin shaving of the bark is all that is necessary, for it has been proved by Howard that the chief seat of the quinine is the outer bark, and this is especially the case with red barks.

The inner bark, though rich in alkaloids to a certain extent, does not contain nearly so much quinine in a state capable of crystallisation. In shaving, the cambium is left protected by a layer, so that little check is given to the tree, and, when immediately covered up, the process of renewing commences after a few days. In the experience of the writer, six-year-old trees have been twice shaved during a year, and showed no evil effect from the operations. A man can bring from four- to six-year-old trees about 70 lbs. of wet bark per day, from older trees about 100 lbs. The ordinary cast-iron spoke-shave is the best implement to employ for the purpose. It is advisable to cover the trees immediately after they are shaved.

Coppicing.—This method of cutting down is condemned by many, but there are frequently reasons for employing it. In coppicing there is the advantage of obtaining quill bark; and the higher prices compensate the needy proprietor. Since the system of shaving became universal, coppicing is considered suicidal. There is never any difficulty in raising a second stem from a stool; even trees cut down on account of canker soon sprout and throw out any number of suckers. It is well to allow coppiced trees to grow two or more stems, and many of them are more vigorous in growth than the parent tree ever was.

The following system of coppicing has frequently been adopted by the writer where there are more stems than one:—After the first has been shaved and the tree nicely renewed, it is cut down, and a sucker allowed to take its place. At the same time the other stem is shaved so that next season it may be coppiced. A very simple arrangement can be carried out on estates where there are trees of all ages, by coppicing a certain number every year.

Doubts at present exist whether beneficial results are likely to continue from shaved trees, so that the system of producing stems for coppicing may lead to further experiments. A small cross-cut saw should be used in coppicing, and the cut should be at a slight angle, a few inches above the ground.

Stripping was first adopted by the late Mr. M'Ivor. In Ceylon it is a simple failure in practice, and gives a poor return for the trouble. It can only be carried out at certain seasons, and with certain trees, and not always without injury to the cambium. When the stripping is carefully done, and the tree is covered up immediately, the bark soon renews.

Uprooting.—"The last thread is broken that binds that golden chord." This cannot be considered as a regular means of harvesting. The small quantity of root bark obtained will never redeem the loss of the tree. Only in the case of dying trees, or when thinning out a clearing, is such a work necessary. Such a course as uprooting a whole field and replanting has never proved a success in Ceylon.

In a cool climate, as at "Newera Elliya," and other high elevations, covering is unnecessary, and also in a closely-planted field, where one tree can protect another from the direct rays of the sun. Grasses are probably the cheapest and best covering material, being superior to cocoa-nut fibre or any other manufactured material. A current of fresh air should always be able to pass through the covering. Dried grass should always be used; wet or green material is apt to cause canker and rot. A thick covering is unnecessary; all that is required is a simple shade from the sunlight. For tying on the grass the leaves of the green aloe, *Fourcroya gigantea*, split into strings, are very useful, and it is plentiful all over the island.

The following is a list of the principal covering materials:—

Panicum jumentorum; Guinea grass, the best cultivated grass in the island.
Panicum barbinoe; Mauritius grass, grown in marshes.
Panicum sanguinale and *migonum;* good hill-pasture grasses.
Arundinaria debilis; good fodder grass, and very abundant.
Andropogon Martini; manna; this may be considered the best thatching grass, and is very plentiful.
Pteris aquilina; the bracken; makes splendid covering.
Pteris biaurita; this fern is much used in shading.
Lycopodium clavatum; common club moss; "badge of the Sinclairs."
Lycopodium cornuum; plentiful in marshy land.
Lygodium scandens; very useful.
Gleichenia dichotoma; very useful.
Oryza sativa; rice plant, paddy straw; is well known.
Cocos nucifera; cocoa-nut palm; the dry plaited leaves form one of the best coverings.

Drying Bark.—Sun-drying is generally adopted; however, if possible, I prefer to dry the bark under an iron roof, and never put it in the sun. In cold and wet districts artificial means of drying are often necessary, and where firewood is plentiful a drying-house with hot-air pipes may profitably be erected. Bark should be dried until quite crisp. Quill requires a great deal of drying. Ordinary quill and shavings dry down to about one-third of their original weight. The bark should never be allowed to mildew; if it does, its market value becomes greatly depreciated.

Harvesting Season.—The first and most important point to consider is the season of the year when the bark is richest in alkaloids. From the result of Indian experiments it is customary in Ceylon to adopt what has been proved to be the best harvesting season, just before the bursting of the south-west monsoon, in the months of April and May; and this is also the best season for drying the bark. In shaving also it is necessary to consider the best season for carrying on the work with least risk of injury to the tree. In the western planting division of Ceylon there is only one harvesting season, while in the eastern division, with its more genial climate, harvesting can be carried on from March to May, and again in August and September. Two years ago my trees were shaved in August and September; they never showed the least check in growth nor reddening of foliage, and the bark was rapidly renewed. The shavings, when sold in the London market, fetched the highest price at that time. Cinchonas have been shaved twice a year with no evil effect. During the last few years everything, from a three-year-old plant upwards, has passed through that operation. No doubt the quantity of poor bark that has been sent into the market lately accounts for the great fall in prices; however, a rise must come, seeing that little but quill is now harvested.

Manuring Cinchonas.—The writer has carried out a few experiments in manuring cinchonas, but with comparatively little result in the way of increase in the alkaloids, although the growth and the foliage were much improved. Well-rotted cattle manure, bone dust, and superphosphate of lime, may be classed as suitable manures. The experiments of other planters in manuring cinchona trees seem not to have shown an increase in the growth of the trees to which the manure was applied, but to have indicated a marked influence on the quality of the bark. It was shown, in the case of red-bark trees, that manure had the effect of slightly increasing the total yield of alkaloids, while the proportion of quinine was reduced.

Changes in the bark according to the age of the tree.—According to several experiments it has been found that a deterioration in the alkaloids commences after the tenth year. This is especially the case with red barks; with crown barks deterioration does not begin until later. This subject is very important, and should be closely studied by all cinchona-growers. By promoting rapid growth the amount of quinine in the bark is increased. At low elevations the bark contains proportionately less quinine and more cinchonine. The observation of this fact has recently led to numerous experiments in Ceylon, with samples of bark from various districts and altitudes, and the results obtained have been of practical utility.

Diseases and Enemies.—Canker in the stem at the base of the tree is the most grievous and fatal visitant. It is held by many to be infectious, but personal observations lead the writer to a different conclusion. Much attention has been given to the subject of canker lately; numerous letters have been published and many strange cures proposed. The whole remedy really lies in the suitability of the soil, in proper drainage, and in a moderate rainfall equally distributed over the year. It is thus purely a matter of situation, climate, and cultivation.

The cinchona caterpillar, larva of the *Oleander moth,* is the most destructive pest among young trees, and often in the course of a night these caterpillars eat down young plants to bare sticks. Hand-gathering is the only effectual remedy.

Deer are at times unwelcome and injurious visitors.

Beetles frequently attack the leaves, but the damage done by them is slight.

IS CINCHONA CULTIVATION TO CONTINUE REMUNERATIVE?

The important question before the planter is, Is an over production of cinchona bark likely to lead to unremunerative prices? There are indications already of such a state of things. During the last two years prices have gone down to about one-half, and there is no decrease in the cost of quinine. Possibly this may be due to the great quantities of South American bark reaching the market, and also to the fact that much inferior bark is shipped from the East. The demand in India alone would almost meet the supply of quinine at present manufactured.

When the Indian Government set about the introduction of cinchona, they were fully alive to the interests of that vast country, with its poor and fever-stricken inhabitants. However, to millions this valuable drug is still out of reach, owing to its great expense: it is as yet a medicine for the rich, and not for the poor. Since the death of that great quinologist, Mr. Eliot Howard, the manufacturers' syndicate has divided, and already the result is a fall in the price of quinine, with a better market for the bark.

The vegetable kingdom has been vainly searched for an efficient substitute for quinine. All attempts to produce the alkaloid artificially have proved unsuccessful. Considering that not over one-third of the cinchona planted ever reaches five years of age, any one owning a successful cinchona estate may be classed as very fortunate, and as having every chance of reaping a handsome reward. Quinine might be sold at six shillings per ounce,[1] a price that would enable the poorer classes to purchase largely, and yet give a good return to the grower.

Planters might also improve their position by growing nothing but the richest quinine-producing varieties.

I maintain that Ceylon has many advantages for producing bark cheaper than any other country, and am confident that cinchona cultivation will remain a paying investment there for many years to come.

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[1] It has recently been sold in England at less than five shillings per ounce (1885).—Eds.

The cost of opening and cultivating a cinchona estate until self-supporting may safely be rated at about £30 per acre. The rainfall in the hill districts of Ceylon varies very much according to aspect and elevation, ranging from 80 to 110 inches per annum.

The following are prices obtained for Ceylon cinchona bark in the London market:—*Succirubra,* 5s. 4d. per lb., from Kirklees estate; *Officinalis,* from 10s. to 15s. per lb.; *Succirubra* shavings, 2s. 6d per lb.; *Officinalis,* 3s. per lb.; *Officinalis,* renewed under grass covering, 5s. per lb. Ceylon *Ledger bark,* from four-year-old trees, gave 14·50 per cent. sulphate of quinine, and was valued by Messrs. Howard at 17s. per lb.

THE MANUFACTURE OF CINCHONA ALKALOIDS.

Local manufacture of the alkaloids, of which the most important are quinine, quinidine, cinchonidine, cinchonine, and amorphous, would be particularly advantageous to the planter, enabling him to find a ready market for all inferior bark not worth exporting.

A factory was opened in Sikhim about 1875, where a febrifuge, under the name of quinetum, has been manufactured at a cost of one rupee (1s. 8d.) per ounce. The success of the quinetum as a febrifuge, in doses of three to four grains, is beyond all doubt. Recent experiments by Mr. Gammie, in the same factory, have resulted in the successful manufacture of quinine.

It is evident that we are approaching the time when overestimation of quinine must give way before the advantages of employing the mixed alkaloids.

The Zimmer manufactory at Frankfort-on-the-Maine makes vast quantities of sulphate of cinchonidine for export to the United States at a price equal to one-third of that of sulphate of quinine.

Mr. Howard's opinion as to the value of the respective alkaloids, is that cinchonidine is in no sense inferior to quinine, though somewhat different from it in its operation, and in some cases to be preferred; quinidine is equal to cinchonidine, and cinchonine is as powerful as quinine.

Table of Average Returns in Bark and Sulphate of Quinine.

	TREES FIVE YEARS OLD.					TREES EIGHT YEARS OLD.				
	Shaving per Tree.	Shaving per Acre.	Coppicing per Tree.	Coppicing per Acre.	Percentage of Quinine.	Shaving per Tree.	Shaving per Acre.	Coppicing per Tree.	Coppicing per Acre.	Percentage of Quinine.
C. succirubra, . . .	7 ozs.	400 lbs.	2½ lbs.	2000 lbs.	2·25	14 ozs.	750 lbs.	4 lbs.	3500 lbs.	3·20
C. robusta, . . .	8 ,,	500 ,,	3 ,,	2500 ,,	3·00	16 ,,	800 ,,	4½ ,,	4000 ,,	3·72
C. officinalis, . . .	4 ,,	250 ,,	1¼ ,,	1200 ,,	4·00	8 ,,	420 ,,	2¼ ,,	2000 ,,	4·20
C. Calisaya, . . .	4 ,,	250 ,,	1¼ ,,	1200 ,,	2·50	8 ,,	420 ,,	2¼ ,,	2000 ,,	2·70
C. Ledgeriana, . . .	5 ,,	300 ,,	2 ,,	1600 ,,	6·00	12 ,,	700 ,,	3½ ,,	3000 ,,	9·00

Cinchona Area planted in Ten Years in Ceylon.

	1874	1875	1876	1877	1878	1879	1880	1881	1882	1883
Acres, ...	2000	3000	4200	5578	10,000	20,000	33,568	45,000	55,000	64,000

Export of Cinchona Bark for Ten Years from Ceylon.

1874, . . .	40,300 lbs.	1877, . . .	72,100 lbs.	1881, . . .	1,314,500 lbs.
1875, . . .	19,100 ,,	1878, . . .	187,000 ,,	1882, . . .	4,656,000 ,,
1876, . . .	15,000 ,,	1879, . . .	507,300 ,,	1883, . . .	7,000,000 ,,
		1880, . . .	1,162,000 ,,		

IX.

NOTE ON THE VEGETATION OF WESTERN AUSTRALIA.

By A. Milne Robertson, M.D., *London.*

The Western Division of Australia comprises all that part of the island continent situated to the westward of 120° east longitude, and extending between the parallels of 12° 34′ and 35° 13′ south latitude. Its length from north to south is computed at about 1200 and its breadth at about 800 miles, its area being approximately 1,000,000 square miles.

The chief physical peculiarities of the more settled or south-western parts of the Colony are produced by the Darling range of mountains. This range commences on the south coast about twenty miles to the east of Cape Leuwin, near Flinders Bay, and runs almost directly north for 500 miles parallel to, and about twenty miles distant from, the western coast-line; it ultimately approaches the sea at Irwin Bay. Its height varies from 1000 to 1500 feet.

The country between this chain of mountains and the coast is composed of sand ridges, averaging from 30 to 40 feet in height, and running in lines parallel to the coast. Lakes or reedy marshes are frequent in the spaces between these ridges, but the land they cover becomes very productive when drained and cultivated.

Numerous rivers, running from east to west, traverse this country. The majority of them are small, and are actual rivers only in winter, being during summer mere chains of pools. The whole of the district, including the range of mountains, is covered with bush, and in many parts richly laden with timber. The land to the east of the Darling range, or "over the hills," as it is termed, is largely made up of sand plains, fit only for grazing purposes. The north-west of the Colony is not yet well known, but the Surveyor-General reports, as the results of a recent survey, that the country is covered with a luxuriant crop of grass about 6 feet in height, and is in some places thickly covered with a stunted variety of *Eucalyptus calophylla* and other trees. The forest districts in Western Australia are estimated to occupy an area of about 30,000 square miles. They extend generally over the hill-country, as well as on the plains to the south-west, and to the east of King George's Sound, where they disappear. The Eucalypti, or Gum-trees, are most abundant in, and so give the special character to, these forests. Of this genus of tree there are about 100 species, and of these the following are the chief:—

Eucalyptus	*rostrata,*	or the	Red Gum.
„	*marginata,*	„	Jarrah.
„	*diversicolor,*	„	Karri.
„	*goniocephalus*	„	Tooart.
„	*viminalis*	„	White Gum.
„	*coxophela*	„	York Gum.

In addition to their commercial value, the Eucalypti are not devoid of medicinal properties. The leaves have long been used by the colonists in various ways. Externally, as fomentations, they are useful in inflammatory affections, swellings, etc., and a simple decoction frequently acts as a charm in cases of inflamed eyes. *Eucalyptus rostrata* furnishes the common red gum, which is a valuable astringent, and may be considered a specific in cases of dysentery and diarrhœa. It must be employed, however, with caution, otherwise it may bring about more terrible results than the disease it is intended to cure. The red gum also makes an excellent astringent gargle, and is so used by the colonists in a form of sore throat prevalent in some districts during the early summer months.

Eucalyptus marginata—the Jarrah, or, as it is locally named, the Swan River Mahogany—has become the most important of all the Eucalypti as an article of commerce. It is only found in the south-western districts of Western Australia, where it covers an estimated area of 14,000 square miles.

The finest trees grow on the summit of the granitic and ironstone ridges lying to the south of Perth, those grown on the sandy plains nearer the sea yielding a timber of inferior quality. Many noble trees, varying from fifty to sixty feet in height clear of branches, and having a girth of from ten to twenty feet, are to be found in the forests. Their foliage is evergreen, and just after the hot season they are covered with large bunches of white scented flowers. The strength and durability of this wood has been amply proved in the course of its extensive use throughout the Colony. "In the old jetty work at the port of Fremantle, piles which have been driven in thirty years and others only about a year could scarcely be distinguished, both being equally sound. Large iron bolts through them have entirely corroded away, leaving the holes clean and sound. Round piles, with only their bark peeled off, driven before seasoning, appear to stand as well, if not better, than those which were squared and seasoned. Young, as well as matured wood, had effectually resisted the attack of sea-worms. A cargo boat, upwards of twenty years old, exposed at all times, and as often high and dry as afloat, is as sound as when it was launched. Coasting craft, which had been more than ten years afloat, without copper sheathing, are perfectly seaworthy, not a plank perforated or a butt-end rotten. A sapling pole, sheathed with copper and guyed with iron chains, which had been set up to mark a shoal near Fremantle, was found on inspection to be uninjured after twenty years' exposure. A chip was taken from the water-line, and looked like cedar; the copper sheathing and iron chains had both perished. Land boundary posts, put in forty years ago, show neither weathering, rot, nor injury of any description; letters cut on them are still clear and sharp. This is the case also with slabs in the cemetery of Perth, bearing inscriptions 1834. Flooring of cottages, wet or dry, according to the season, being laid on the ground without joists, after twenty-five years shows no signs of decay on either side."[1] Large quantities of the Jarrah have been exported for public works to New Zealand, where its qualities, when used for railway purposes, are highly spoken of. In consequence of the great demand, several companies are engaged in felling and cutting work, great activity, for example, being manifested at Jarrahdale and Lockville, Vasse Inlet, Geographe Bay.

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[1] *Handbook of the Colony.* By Rev. C. G. Nicolay, Fremantle.

The little town of Jarrahdale, with its 400 inhabitants, its picturesque wooden houses, and its extensive mills, is delightfully situated in a glen among the hills, to the south of Perth, and eighteen miles from the coast, with which it is connected by a railway. It has a post and telegraph office, a savings bank and money order office, stores, a Good Templars' lodge, a reading-room, a library, an assembly hall, and a Government school. There is no public-house within many miles. At the coast there are suitable buildings for the storing and shipping of timber, and other purposes. There are two jetties —one 445 feet and the other 300 feet long. In this place the Jarrah trade is prosecuted with much energy, upwards of 200 men, 45 horses, numerous bullock teams, and several locomotives being steadily employed.

Lockville, with its mills, is also a small town, situated on the beach near the jetties. It possesses all the advantages enjoyed by Jarrahdale, and from it a railway thirty miles in length extends into the forest, about 250 men being actively engaged in connection with Jarrah industry. In both these centres the health of the inhabitants is remarkably good.

Eucalyptus diversicolor, or the Karri Tree, may be regarded as the prince of Eucalypti. Its habitat is the district known as the Warren, situated in the south-west part of the Colony, not far from Cape Leuwin. It covers an estimated area of 2300 square miles.

It is a very noble tree, of gigantic proportions and graceful appearance. It is perfectly straight in growth, and its bark is smooth and of a light colour.

The average height of this species varies from 150 to 300 feet, but many exceed this before the first branch is reached, and many of the branches are themselves large trees, having been found from 100 feet to 150 feet in length.

Their average diameter varies from six to twelve feet, although many exceed the latter figure. On first entering the Karri forest, the visitor feels quite giddy on looking up at these enormous trees, and is in a sense oppressed by their size and beauty. A visit to such a forest is alone worth a trip from England.

That these enormous giants exert an influence on the climate of the district cannot be doubted, the whole atmosphere being impregnated with a pleasant aromatic odour issuing from them. This odour is especially noticeable in the early morning, and it produces an agreeable feeling of invigoration, accompanied with a desire for exercise. The inhabitants of the locality all enjoy excellent health, and strict inquiries revealed the fact that no severe illness had occurred in the Karri District within the memory of the oldest inhabitant, while invalid visitors almost invariably improved in health. The whole Warren district is abundantly watered by permanent streams, most of them containing a trace of iron. The summer is not hot, nor is the winter cold, and I know of no more delightful climate. I even venture to predict that, at no distant date, the Karri forests of Western Australia will become a health resort of the utmost value, not only to invalids living in Australia, but to many others from the mother country.

Karri timber is quite as valuable, from a commercial standpoint, as Jarrah, but its huge size prevents it from being extensively used. Its durability may be judged from the fact that a log, which had lain at Augusta for thirty-five years in the wash of the tide, was found, when examined on its arrival at Busselton, to be perfectly sound.

Although all the other species of Eucalypti are of more or less commercial importance, either on account of their timber or their gum, yet they are by no means the only valuable trees in Western Australia. Sandalwood, for example, grows pretty generally throughout the eastern districts. Large quantities of it are exported yearly to China and India. It has a fine grain, takes on a beautiful polish, and is used for ornamental work, as well as prized for its perfume.

The Banksia wood, which produces large quantities of resin, is used for cabinet purposes. The Raspberry Jam tree, so called from its peculiar scent, and known also as the Mangar, has a hard wood, much employed for the manufacture of furniture.

The Tea Tree, or Paper Bark, grows abundantly by the sides of marshes and rivers, and is used by the settlers for roofing, as well as for carriage-work.

The Shea Oak is common everywhere, its dark, hard, heavy wood being employed in house-building.

Various Acaciæ yield a gum closely resembling the gum-arabic of commerce, while certain species have astringent barks, and are named Wattles,—the Black Wattle furnishing a bark valuable in tanning. The Black Boy and Grass Tree, belonging to the order *Liliaceæ,* and the Zamia, belonging to the *Cycadaceæ,* are characteristic of the vegetation of Western Australia. The first is peculiar, inasmuch as its stem somewhat resembles a palm, and grows to a height varying from seven to ten feet. On the top of this stem there is formed a tuft-like head of "rushes," from the centre of which a long narrow spike of flowers springs to a height varying from six to twelve feet.

From this tree there can be manufactured a very fair gas, with which the convict establishment in the Colony was for some time lighted.

The second is taller and thinner than the first, and its head is formed of long wavy "grass."

The base of the head is very sweet and succulent, and is eaten by the natives. Both these trees yield a very useful fragrant resin, which is in great demand in the English market.

The Zamia resembles a gigantic pine-apple, provided with a crown of fronds like a palm. It is amylaceous, and an excellent arrowroot can be made from it, 14 lbs. of the centre of the stem yielding 1½ lbs. of arrowroot. Its nut is used by the natives, after undergoing some special preparation, without which it is poisonous.

The indigenous flowers are very brilliant, but as a rule short-lived. September and October are the chief months for them. Their cultivation in gardens, however, has not been a success. Ferns and grasses are rare. Seven edible fungi are found in the Colony, and afford valuable food to the natives. About one-fourth of the entire vegetation belongs to the orders *Leguminosæ* and *Proteaceæ.*

Although there are no fruit-trees of any importance indigenous to the Colony, nearly all the European, and many of the Asiatic, are successfully cultivated. Vines grow well, and fair ordinary wines, such as are used in Hungary and the north of Italy, are made. In common with all Australian wines, they contain a much higher percentage of alcohol than the average of natural European wines. The climate of the Colony is admirably adapted for drying fruit, and raisins of good quality could easily be made. The fig, olive, almond, and mulberry trees all grow well. Bananas thrive vigorously near the lakes, marshes, and rivers. The melon tribe grows to an enormous size, while orange and apple trees abound. Pomegranates are grown, but with little success. The castor-oil plant has become a weed, and spreads at an amazing rate in any place that happens to be temporarily neglected. Tobacco and cotton are successfully grown at the Roman Catholic Mission at New Norcia.

Oats grow well in the south, and wheat, barley, and maize throughout the Colony, while potatoes thrive, and give a large return.

Farming, as presently carried out, is in a very primitive state all over the Colony. Selection of soil or locality is never attended to. The land is either ploughed two or three inches deep previous to sowing, or it is not ploughed at all; and the straw is burned after harvest. This process is repeated year after year, without manuring the land, which ultimately becomes useless. The farmer thereafter looks out for fresh ground, which he cultivates in the same manner, and no attempt is ever made to improve exhausted soil.

X.

THE FORMATION AND MANAGEMENT OF EUCALYPTUS PLANTATIONS.

By E. J. C. Brace, *Les Vaux, Salbris, Loir et Cher, France.*

For fifteen years past or upwards the experimental cultivation of several species of Eucalyptus has been carried out in the Nilgiri Hills of Southern India, in Algeria, Italy, and various parts of the south of France, but only in the two first-named localities have the operations been conducted on a sufficiently extensive scale to prove of interest from a forester's point of view. So far, however, sufficient time has hardly elapsed to allow of a fair estimate being taken of the value of the Eucalyptus as a forest tree, as well as of its powers of draining marshy lands and of counteracting the influence of malaria—a malady probably due to the presence of noxious gases in the atmosphere of certain localities;[1] but in all those countries whose soil and climate will allow of its making fairly vigorous growth, it will be pointed out in the sequel how highly beneficial its extended cultivation may be made on economical as well as on sanitary grounds.

While in every country the trees that exist spontaneously are those best suited to the conditions of soil and climate in which they are placed, Nature allows a certain scope, within the limits of which, the physical conditions being the same or nearly so, the cultivation of exotic trees and plants may not only be carried out with success, by becoming reconciled to the altered circumstances in which they are placed, but may also convey from generation to generation of their offspring a greater degree of hardihood, and in some instances develop certain peculiarities of form and habit.

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[1] This gas rises to a height of about sixteen feet above the level of the ground, and is removed by certain trees, notably the *Eucalyptus globulus*, and also, though to a much less extent, by the Scots pine.

This is very clearly illustrated in the case of the different varieties of the Scots pine, extending as it does, in one type or another, throughout the temperate climates of Europe, from Riga in the extreme north to the islands of Hyères in the south, and changing but very gradually its form and habit, according to its surroundings. It hardly needs a practised eye to detect the difference between the upright symmetrical habit of the Riga pine and the variable form of the Scots, or the still more straggling and bushy growth of the Geneva pine. Such variations also occur among bamboos in different tropical climates, and in many other instances.

The course of time which has effected the change in these cases may do the same with regard to the Eucalyptus, and ultimately remove many of the difficulties that are now attached to its cultivation in some parts of Europe. As a rule, it may be safely laid down that the more useful varieties of Eucalypti are strictly sub-tropical plants, and that they may be cultivated with the greatest chance of success south of that degree of latitude at which the Scots pine ceases to grow with ordinary vigour, and north of that in which the bamboo is found to succeed. Like all plants that have been given by Nature a wide distribution, they fulfil in their several varieties a vast number of purposes, exercised not only on their immediate surroundings, but also in the uses to which they can be applied, and probably no family of trees is possessed of a higher value in forest economy.

Before going any further, it may be as well to give a few brief notes on the botanical position occupied by the Eucalyptus.

The genus belongs to the *Leptospermeæ* division of the natural order *Myrtaceæ*, a tribe which is described as follows by MM. Le Maout et Decaisne:[1]—

"Stamens very often indeterminate, free or polyadelphous, rarely monadelphous. Ovary bi-multilocular with several ovules, seldom a single one, in each cell. Capsule with loculicidal or septicidal dehiscence, seldom indehiscent. Seeds sometimes dimorphous (*Eucalyptus, Fabricia*, etc.). Shrubs or trees, abundant in Australia, less numerous in tropical Asia. Leaves opposite or alternate, without stipules, entire or seldom denticulate, pinnate, occasionally presenting the appearance of phyllodes."[1]

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[1] *Traité Général de Botanique.*

The genus Eucalyptus is most closely allied to that of Metrosideros; and the winter temperature given as being best suited to its cultivation varies from 35° to 45° Fahr. A single species, *E. persicifolia*, is said to be a native of the Cape of Good Hope, the others are all natives of Australia and Tasmania.

Baron F. von Müller, Director of the Botanic Garden at Melbourne, the greatest living authority on the subject of Eucalypti, and probably on all other matters connected with the Australian Flora, has enumerated, it is said, upwards of three hundred distinct species, ranging in habit of growth from those that never exceed the limits of a dwarf shrub up to the towering height of 300 or 400 feet, attained by *E. amygdalina* and *E. diversicolor*, dimensions which almost cast into the shade those reached by the finest known specimens of Californian Sequoias. It is not, however, intended here to do more than allude to those, which, from their freedom of habit, rapidity of growth, value of timber, sanitary influence on their atmospheric surroundings, and capacity for withstanding greater extremes of climate than are met with in their natural habitat, seem specially capable of successful cultivation in European countries.[2]

Before going further into the details connected with the propagation and cultivation of Eucalypti, the following short list of the varieties that have proved themselves, according to the results of my observation and experience, to be those best adapted for cultivation in Europe, together with a few brief notes on their growth, habit, and the relative value of their timber, may be of interest. It must not be imagined, however, that this is put forward as a complete catalogue of all the varieties worthy of cultivation: doubtless there are many more of equal value whose merits could only be satisfactorily ascertained by careful experiment.[1]

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[1] *Gardener's Dictionary.*

[2] The following are the chief papers that will be referred to in the sequel:—

1. The notes extracted from the excellent report of the Government Conservator of Forests which are given in the Manual of the Nilgiri District, edited by H. B. Grigg, Esq., B.A., M.C.S.; and published at the Government Press, Madras.

2. A not less interesting, though less practical paper, contributed by M. E. Meaume, editor of the *Revue des Eaux et Forêts*, to his periodical (July 1882).

3. A letter that appears in the same journal by Dr. Howitz on the state of the Eucalyptus plantations established by the French Forest Department in Algeria.

It may here be noted that Messrs. Anderson and Co. of Sydney preface their list[2] of useful varieties with the following interesting remarks, the accuracy of which has been fully confirmed :—

"Of late years these woods, and the forests which produce them, have attracted a great deal of attention in Europe, not only for the qualities of the timber, but for other properties, which are being from time to time discovered by science, and promising extraordinary riches in both medicine and the arts.

"As a fuel, both for domestic and industrial purposes, the wood, natural and carbonised, of some species is superior to most others, and for steam purposes some (*e.g.* Ironbark and Box) are only inferior to coal.

"Possessing so many valuable qualities, combined with the fact that these trees are found growing in New South Wales in boundless forests, under extremes of climate, both as to heat and cold, ranging from 130° to 25° Fahrenheit, it may be inferred that forests of them will some day be planted in many other parts of the world."

For present purposes the various species may be arranged in two sections: one containing the few that commence their existence in a herbaceous or soft-wooded state, and which are perhaps, up to the time when they change the form and nature of their foliage, and harden their outer bark, somewhat more sensitive to frosts; the other composed almost entirely of the varieties known in the Colonies as Red Gums and Ironbarks, which undergo no transition in the nature of their growth, and which are therefore, as a rule, capable of withstanding greater extremes of climate. Many varieties are, from the fact that they are generally inferior in merit to those named, left out of consideration.

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[1] This will indicate the desirability of establishing, in every country in which the Eucalyptus is found to succeed, experimental nurseries and plantations on the same system as that practised at the Domaine Forestier of Barres Vilmorin (Loiret), which is now the property of the French Government.

[2] This list has been arranged by T. W. Shepherd, Esq.

1. *Eucalyptus globulus*, the Blue Gum. This species is a native of Tasmania, where it attains a height of 250 feet and upwards. It is better known than any of the others, and up to the present time is that most generally cultivated in Europe. It yields timber, when mature, of most excellent quality. "The wood of the *Eucalyptus globulus* is certainly much inferior to teak for the interior fitting of houses, etc.; but it is known to be a valuable building timber, and it is largely used in Australia for beams, joists, rafters, and in out-door work, for piers, bridges, fence-rails, railway-sleepers (duration about nine years), also for shafts and spokes of drags, and a variety of other purposes."[1] From the rapidity of its growth, its power of disinfecting malarious localities, and of draining water-logged lands, it is by far the most generally useful of all the varieties known. It is certainly that best adapted for cultivation on a large scale in all those climates in which it can be maintained in a fair state of vigour. In all tropical countries where it is exposed to long periods of extreme heat—as in experiments conducted at Lucknow, Cawnpore, Assam, and the Malabar coast—it is not found to succeed; while some varieties of Red Gum, though they fail to make satisfactory growth, show a greater degree of hardihood. In such conditions the most likely tree to succeed is the Casuarina (*Casuarina torulosa*), the cultivation of which as a fuel tree on a large scale has proved highly remunerative in the neighbourhood of Madras. The same remarks will apply to the other species in this section, except, perhaps, *E. coccifera*, which has the reputation of being extremely hardy. On the Nilgiris the Blue Gum grows to the best advantage between the elevations of 5000 and 7500 feet.

The wood of the first thinnings, taken at the age of six years, though sappy, may be turned to various useful purposes. Between the tenth and fifteenth years the heart-wood has begun to harden, but is not really of first-rate quality until the tree has attained from twenty-five to thirty years of age—from which period up to its seventieth year, or even longer, it goes on steadily increasing both in volume and density. It has been proved, both at the establishment at Troisfontaines and at Ootacamund on the Nilgiris, to be capable of withstanding a considerable number of degrees of frost, but at the same time all the varieties noted in this section require somewhat more attention during the first three years of their growth than do the more slowly growing and hardier Red Gums. They are also perhaps a little more capricious in starting into growth immediately after transplantation, but their subsequent rapid progress will amply compensate for the small amount of additional care that is bestowed upon them. In the case of exposure to frost, it must be borne in mind that it is not so much the actual degree of cold sustained that does the harm, as the subsequent direct action of the sun's rays upon the frozen surface. The cost of the seed of this species is 17s. 6d. per lb.

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[1] *Manual of Nilgiri District.* Edited by H. B. Grigg, Esq., B.A., M.C.S.

2. *Eucalyptus obliqua*, or the Stringy Bark, is a native of New South Wales. It closely resembles the preceding, and grows almost as fast. In Australia, slabs of its bark are used for roofing sheds, outhouses, as well as for other purposes. As a sanitary agent it is probably hardly inferior to *E. globulus.* Messrs. Anderson say that it is "the best wood for flooring-boards, rafters, and sawn stuff generally."[1] It is of very quick growth, but produces inferior fuel, yet it yields the best charcoal for the forge. Its height is about 120 feet. Its seed is priced at 20s. per lb.

3. *Eucalyptus hæmastoma*, or the White Gum, closely resembles *E. globulus*, but it may be distinguished from it by the lighter and more silvery colour of its foliage, especially when in the herbaceous state. Its wood is indifferent, and attains but moderate dimensions. Its seed is priced at 30s. per lb.

4. *Eucalyptus coccifera* is a native of Southern Australia. It is a very ornamental variety of rapid growth, and is stated by MM. Vilmorin, Andrieux, and Co., to withstand frost better than any other. My own observation of it has been confined to a few young plants in the Jardin d'Acclimatation at Hyères,

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[1] Anderson and Co., Sydney, *Catalogue*, p. 76 (1883).

where it seemed to be in a most thriving condition and making vigorous growth. It seems likely to prove a most promising subject for general cultivation.

It is probable that *E. diversicolor* should be included in this section.

In the second section the more valuable kinds of Red Gums and Ironbarks are more important for the excellence of their timber than for their rapidity of growth, and as sanitary agents their influence, though powerful, is in some instances less directly felt. On the whole they are, as above noted, capable of withstanding greater extremes of climate.

1. *Eucalyptus calophylla* is a native of the Swan River district in Australia, and is a very handsome, fast-growing variety, with large bright coriaceous leaves, and a more spreading habit of growth than is common to most Eucalypti. On this account it has been recommended by some as suitable for planting in avenues and in towns, but no member of the genus is very well adapted for such purposes, especially as there are so many other trees (planes, maples, ficus, etc.) that give more shade, and thrive better in a smoky atmosphere. Hence, save where sanitation is the object in view, the planting of Eucalypti in such sites can hardly be recommended.

E. calophylla is one of the most important of the whole class of Red Gums, exceeding as it does in rapidity of growth all others, save those named in the first section, and forming a pleasing contrast when planted among them by the bright and vivid colouring of its foliage. It is not less remarkable for the excellence of its timber. It possesses many advantages to recommend its cultivation on a large scale, especially in those countries where the successful cultivation of Eucalypti may seem doubtful. In common with most of the Red Gums, it flowers and produces fertile seed at an early age, its flowers being larger and more striking than those of any other variety. The wood is fine, close, and handsomely veined, and is, in conjunction with *E. rostrata* and *E. marginata* (Jarrah), classed as mahogany in the Colonies, and used for all the purposes to which that wood is put by us. This, with the four following varieties (and perhaps *E. diversicolor*), may be confidently recommended for general cultivation in Europe. It has been planted in considerable numbers on the Nilgiri Hills, though chiefly as an ornamental tree, and is making most satisfactory progress.

2. *Eucalyptus siderophloia*, or the Broad-leaved Ironbark, is the fastest-growing and most valuable of all the Ironbarks. Its timber can hardly be surpassed, save by the mahoganies, for carpenter's and joiner's work. Messrs. Anderson and Co.[1] speak of it as affording "most valuable wood for piles, girders, railway sleepers, and for every purpose in which strength and durability are required," even shingles a quarter of an inch in thickness being known to last sound on roofs for forty years. This species and the two following (*E. paniculata* and its variety *microphylla*) are the strongest of all Australian timbers, and are used for a great number of purposes,—spokes, shafts, poles, frames, etc. It furnishes the best telegraph-posts and fencing of all kinds, and no other varieties are equal to it for cogs in mill-work. It is superior to most as fuel for steam-engines. It grows to a height of 150 feet, and its seed is priced at 30s. per lb.

3. *Eucalyptus paniculata*, or the Common Ironbark, and its variety *microphylla*, agree with *E. siderophloia* in producing valuable timber. They have made good growth on the Nilgiris; but it is doubtful if they would make the same progress in European climates. They are, however, worthy of trial. The seed is quoted at 40s. per lb.

4. *Eucalyptus sideroxylon* is very similar in all its characteristics to *E. siderophloia*, save that the leaves are smaller and the growth somewhat less vigorous.

5. *Eucalyptus leucoxylon* is a species of Ironbark, bearing a marked resemblance to the preceding. According to Dr. Howitz, it is esteemed both on account of the toughness and hardness of its timber. It is extensively used in shipbuilding, as well as for wagons, handles, and generally for all purposes where "strength, elasticity, and hardness are considered necessary."[2]

6. *Eucalyptus resinifera*, or the Common Red Gum, is a native of New South Wales. It is better known, and has been cultivated more extensively on the Continent and in Algeria

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[1] Anderson and Co., *loc. cit.*

[2] *Revue des Eaux et Forêts*, p. 514 (1882).

than any other species, except the Blue Gum. Its growth, however, is not quite so rapid as that of *E. calophylla* or *E. siderophloia*, and it is not capable of resisting greater extremes of temperature. As its name implies, it has the power of exuding freely from the lower portions of its stem and branches a resinous substance that bears a strong resemblance to copal, a substance whose antiseptic odour is very strong. It is injurious to some forms of vegetation, notably to tea plants, that grow within a certain radius (ten or fifteen yards) of its stem. Its resin is too brittle to have any commercial value. It is found to grow remarkably well on the Nilgiris, where it is more frequently seen than any other form of Red Gum.

7. *Eucalyptus robusta*, or the Swamp Mahogany, is a native of the Swan River, and of some other parts of Australia. It is a very tall variety, of rapid growth, and with the single exception of *E. marginata* (a local grower), it produces the most valuable timber of all the Eucalypti. Messrs. Anderson say that it is "a good lasting timber for house carpentry, and many kinds of turnery."[1] It is not durable in the ground, but for other purposes it lasts well, and is singularly free from the attacks of the white ant. It is not in demand as a wood for fuel. Its specific gravity is great. It attains a height of 150 feet, and its seed is priced at 30s. per lb.

This species is to be recommended on the ground of its making good growth, of its being apparently quite as hardy as any other, and of its value as a timber tree.

8. *Eucalyptus rostrata* is another so-called mahogany, and is, like the former, a native of the Swan River. It is very similar to *E. robusta* both in appearance and in the quality of its timber, but it is a less vigorous grower.

9. *Eucalyptus amygdalina*, or the Almond-leaved Stringy Bark, is a native of Victoria. It is perhaps, with *E. diversicolor*, the most lofty of all Eucalypti, and in fact, of all known forest trees, exceeding in height, if not in diameter, the most gigantic specimens of the Californian *Sequoia gigantea*. It grows fast, and is said to have a great power of resisting frost. From my own observation on the Nilgiris, I failed to see that it grew faster than those named in the first section, or at any

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[1] Anderson and Co., *loc. cit.*, p. 77.

rate it took a longer time in starting into vigorous growth. This, however, need not necessarily be the case in Europe, and the variety is well worthy of trial on an extensive scale. Its febrifugal powers are not very marked. According to Messrs. Anderson, it is "a first-class timber for flooring-boards, joists, and other house carpentry."[1] It is like Stringy Bark, but it attains greater dimensions, and is not so generally distributed. It is a bad wood for domestic fuel, but yields very good charcoal. It grows to a height varying from 150 to 200 feet, and its seed is quoted at 20s. per lb.

10. *Eucalyptus pilularis*, or the Blackhutt, produces wood like that of the Stringy Bark, and is employed for similar purposes. Small spars are used in shipbuilding, being almost the only Eucalyptus so employed. It yields inferior fuel. Its height varies from 150 to 200 feet. Its seed is worth 20s. per lb. This species occurs on the Nilgiris, but is of doubtful value.

11. *Eucalyptus diversicolor*, or the Karri Gum, "is one of the giant trees of South-Western Australia. In those valleys which favour its growth it attains a height of 400 feet, and a diameter varying from ten to fifteen feet. Being of a spreading habit, it is eminently adapted for the formation of shelter plantations. Its growth is rapid, its wood of very excellent quality, and much sought after for shipbuilding purposes. Though preferring a fresh soil, the Karri will grow under adverse circumstances. At the age of five years it will cover the ground, and from that time its growth is very fast. The forest is not worked until between thirty and forty years of age, and care is taken to preserve all the trees for yielding timber of large dimensions. It is chiefly in the Province of Constantine that it makes its best growth. The seed is obtained from North-Western Australia."[2]

Judging from this account by Dr. Howitz, its introduction and general cultivation seem much to be desired.

12. *Eucalyptus bicolor*, or the Black Box, is a highly valued timber tree. It is equal to the best Ironbark for all the purposes for which the latter wood is used, and is more

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[1] Anderson and Co., *loc. cit.*, p. 76.

[2] *Revue des Eaux et Forêts*, p. 512, 1882.

easily wrought. It is sometimes called Ironbark Box. It grows to a height varying from 100 to 150 feet, and its seed is priced at 30s. per lb.

This species will grow on the Hills, and healthy young specimens eight or nine feet high are to be found in perfect vigour at one of the stations between Nantes and Angers. This should be a sufficient guarantee for its hardiness, although the first really severe winter may be expected to terminate its existence, at any rate if the cold is like that of 1879-80.

13. *Eucalyptus latifolia*, or the Broad-leaved Gum, is a singularly handsome, fast-growing variety, chiefly noticeable on account of its lanceolate leaves, which occur in pairs. The colouring of the foliage is less sombre than that of most others.

14. *Eucalyptus citriodora* ⎫ are natives of Victoria.
15. „ *piperita* ⎭

They are also named the Lemon-scented Gum and the Peppermint Gum, and may be classed together. They are singularly elegant and graceful trees, of quick growth, and the latter is as hardy as any other species. The leaves when crushed in the hand give out a powerful fragrance. The distillation of the aromatic oil contained in these has been carried on in Melbourne to some extent.

E. piperita holds among the *Eucalypti* the same place as the silver birch does among our native woods, and the cultivation of these two varieties along the coast of the Riviera, for the sake of the essential oil contained in their leaves, seems well worthy of a trial. The seed of *E. citriodora* is quoted at 10s. 6d. per oz., and that of *E. piperita* at 30s. per lb.

There are many other varieties that attain great dimensions, and yield timber of more or less value; notably among these are *E. colossea, E. grandis, E. longifolia, E. pendulosa*, etc., and the species last named seems, from MM. Vilmorin, Andrieux, and Co.'s description of its rapid growth, to be worthy of trial; but, without proceeding further with the list, the following general deductions may be stated :—

(1.) For sanitary purposes, where rapidity of growth and the speedy counteraction of malarious influence are the chief points aimed at, *E. globulus*, *E. obliqua*, and *E. resinifera*, are those most likely to accomplish the desired result in the shortest space of time.

(2.) Since those European soils and climates in which the Eucalypti are found to succeed best are those which are almost, if not entirely, devoid of indigenous timber trees of any marked value, either for building purposes, carpentry, railway-sleepers, or other similar use, this in itself should be sufficient to induce the State, railway companies, and private landowners to undertake their cultivation on a large scale. Moreover, in the majority of such localities, fuel is both scarce and dear, far more so than in more temperate regions, and a vast and permanent supply of this great necessary of life may be obtained from but a few acres of fairly-grown Eucalypti. The wood of nearly all those above noted burns freely even when quite young, and makes excellent charcoal. The wood of *E. globulus* affords a very excellent fuel for tea furnaces.

(3.) Where the production of timber of the finest quality is the chief object, Red Gums and Ironbarks, such as *E. calophylla*, *E. siderophloia*, *E. robusta*, and *E. rostrata*, are decidedly to be preferred; and that last named will make amends for its comparatively slow growth by the incomparable excellence of its wood.

(4.) There is another great merit attached to the Eucalypti, namely, the fact that many of them come away freely on the poorest soils, provided always that the taproot does not meet with a hard pan at a short distance from the surface. There are few soils, indeed, to which one or other of them cannot accommodate itself, and make fairly satisfactory growth. At the same time, they prefer good fresh loam, and the best growth that I have ever seen has been that of the Ralliah and Old forest plantations on the Nilgiris, where the planting was carried out on the sites of old natural forests, whose timber had been felled for the construction of the barracks at Wellington. Here the secondary growth had attained considerable dimensions previous to its being felled for the planting of Eucalypti.

Probably there is no country in which the necessity for re-afforestation is more keenly felt than in the island of Cyprus, where the land has not only become barren and subject to alternations of severe droughts and sudden deluges of rain, but has also, since the reckless destruction of its forests, which were at the same time its safeguard and principal source of wealth, become notoriously unhealthy. These evils may be readily and profitably counteracted, and that within a reasonable space of time, by the extensive cultivation of Eucalypti on the level grounds and lower slopes of the mountains, replacing them as the land rises by the chestnut, cork, and holm oaks, *Picea Cephalonica*, and at the highest levels by *Pinus pinea* and other mountain pines. Much may be profitably accomplished by private proprietors, but where the work to be undertaken is on so vast a scale, it becomes the duty of the State to step in, as it alone can undertake a work of so great extent with certain profit. From the rapidity of its growth, and the early age at which the thinnings can be made to yield a fair return, more can be made from a small area under Eucalyptus than under any other forest tree.

"High forest," in the words of M. Bagneris,[1] "worked on a long rotation, entails as a consequence the accumulation of a considerable amount of capital, the increase of which is out of all proportion to the increase of revenue that may be derived from it. . . . It is for this reason that the State, and proprietors that are, so to say, imperishable, such as communes and public institutions, are the only bodies that are able to produce the most useful timber. As for the State, it is, in the first place, its bounden duty to grow the most useful timber, because, as the representative of society at large, it is obliged to produce that which the public cannot do without, and which private proprietors are not in a position to produce. With respect to private, and therefore perishable, proprietors, forests stand to them in the same position as any other property; they represent so much capital invested, which they have at their complete disposal, which they can sell, exchange, or employ for any purpose whatever. . . . Their object is to derive from whatever forests they may possess the highest returns consistent with the percentage of profits they expect to obtain. Thus they are driven to choose short rotations in order to guard against the accumulation of a large capital in the shape of standing timber."

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[1] *Elements of Sylviculture*, p. 18.

The above remarks apply to France, where a man's interest in his landed property ceases with his life. With us the case is somewhat different; large landowners can, thanks to the power of entailing property, stand in the place of the State or of communes, so far as the interests of forestry are concerned, and it is to these owners that the existence of our forests in a fairly efficient condition is due. At the same time, their value and importance has not, up to the present time, been so fully recognised as in France or Germany, nor has the science of Economic Forestry been so fully mastered, although a movement in this direction has set in.

With reference to the plantations of the Madras Government on the Nilgiris, it is much to be regretted that their extension ceased so soon as a sufficient area to meet the requirements of the Government had been placed under cultivation. Woods which, as the results already showed, could not have failed to prove highly remunerative from a financial point of view, and which might have gradually restored the vast tracts that have, in these mountains, been rendered permanently barren under a course of indiscriminate felling and reckless husbandry during the course of the past two centuries, might in a few years have exercised a material influence both on the climate and the rainfall, the latter having been seriously affected by the denudation of the upper slopes, more especially on the eastern side of the hills. It must not be inferred, however, that the neglect of so important a work lies with the Forest Department, as it has repeatedly urged its continuation, but the means placed at its disposal barely allow of the efficient conservation of the woods that are left, and leave no balance for works of reproduction. Private landowners receive but little encouragement to take the matter in hand, and the drawback of having their capital locked for a considerable term of years deters the greater number from doing so.

NURSERIES AND PROPAGATION.

Though the sowing of Eucalyptus seed in open nurseries is not likely to be carried on to any great extent in European climates, there are certain localities in which it may be attempted without undue risk, and the following course of treatment is that best adapted for these seeds, as it is, when practicable, the most economical, and that best calculated to produce stout hardy young plants.

With regard to soil and site, what applies to other forest nurseries will hold good equally in this case. The ground chosen should either be perfectly level, or on a slight incline. It should be sheltered from prevailing strong winds, and so inclined as to receive a fair share of morning sun, but northern and western exposures should, save under exceptional circumstances, be avoided. The soil should be, when possible, a fresh, light, and somewhat rich loam, stiff retentive ground being especially objectionable. It must be well drained, as stagnant moisture is very injurious to young seedlings. If possible, the site selected should be by the side of a stream or natural spring of water, failing which, a sufficient underground supply must be available within twelve or fifteen feet of the surface.

Pending germination, and during the earlier stages of their growth, Eucalyptus seedlings should never be allowed to become dry at the root, the surface soil being kept moist, but not in a state of saturation. The land should be trenched all over to a depth of two spits, care being taken to mix the soil of both as evenly as possible. In most instances the upper soil of a nursery is richer than the lower, and should not therefore be sent down to the bottom and buried. The chief advantages gained by deep cultivation are these:—

1. Stagnant water cannot lie within reach of the roots of the young plants, while a free supply of moisture is constantly maintained by capillary attraction.

2. A relatively higher earth temperature is obtained even during the coldest months of the year. Bottom heat is a most important aid in the germination of all seeds. In tropical climates the temperature of the soil is nearly always throughout the year in excess of that of the air; in temperate climates the reverse is the case.

3. The action of frost and of intense heat is less felt, as they penetrate less readily into deeply dug and well-prepared lands, while the moisture derived by night from the dew is absorbed more readily and parted with less freely.

When the land has been thoroughly trenched, and the surface made as fine as possible, convenient paths should be laid out to allow of watering, weeding, lifting, transporting, or other work, after which nothing remains to be done but to mark out the beds.

The length of the latter is immaterial, though in general practice from twenty to thirty yards will be found most convenient. The breadth is of more importance, as the centre must be within easy reach of the paths, so as to prevent the edges from being trodden down during sowing, weeding, and other subsequent operations. On this account a width of 1·1 metre (3 feet 8 inches) will be found sufficient.

With regard to the Eucalyptus seed, it may be noted that if it is fresh and taken from mature trees, germination occurs very freely—under careful treatment 75 per cent. not being an unreasonable expectation. The size of the seed of the different kinds varies greatly, from that of *E. calophylla*, the largest, to that of *E. piperita*, one of the most minute; and careful attention must be given to this point in sowing operations.

Under no circumstances can the practice of forming plantations by direct sowings *in situ* be recommended, and modern scientific forestry is daily becoming more averse to this wasteful system. The additional cost of the seed, the uncertainty of its germination, the unevenness of the crop, the greater frequency and cost of the thinnings, and later on, the irregular growth of the trees in comparison with that of a forest planted with healthy young seedlings, are sufficient reasons for condemning the method.

On the Nilgiris the practice has usually been to sow the seeds broadcast over the beds, covering them afterwards with a light layer of fine soil; but a preferable course by far is to sow thinly in somewhat wide drills, leaving intervals varying from six to eight inches between them.

The instrument used for the purpose of making these drills is a small thrust hoe (termed in French a *ratissoire*), seven centimetres in width, and provided with a blade nine centimetres in length, which is set on a long handle. Thus in each bed of one metre in breadth, four drills and three intervening spaces are obtained. The depth of the drills must depend on the size of the seeds to be sown; but all seeds germinate best when but very lightly covered.

The three chief agents that operate during the process of germination are heat, moisture, and oxygen; and in this connection the following results of experiments on the seeds of the Scots pine, made by Professor Bauer of Hohenheim, are of great interest:—

> "Those buried one-fifth of an inch came up first, but were subsequently less vigorous — they soon, however, acquired vigour;
>
> Those covered from one-third to one-half inch came up more slowly, but were regular and strong;
>
> Those buried from two-thirds to one inch came up in deficient numbers; and
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> Those buried from one to two inches never showed any signs of germination."

The principles that hold good in the matter of Pine sowings are equally applicable in the case of Eucalypti; and it is better to supply the seeds with the necessary amount of moisture by frequent light waterings than to cover them unduly. Care should always be taken not to overcharge the seed-beds with water, as the free action of the oxygen of the air is thereby counteracted. Where space is not very limited, the seeds should be sown somewhat thinly in the drills—each being allowed a minimum space of about half an inch square.

After sowing, the beds, in addition to being carefully watered, should be shaded lightly with ferns, broom, grass, or other suitable material that may be at hand. The direct rays of a powerful sun are decidedly injurious to the young plants until they bear from four to six pairs of leaves, as previous to that time the roots have hardly penetrated far enough downwards to reach in all cases a permanent supply of moisture. At the same time, to insure stoutness and vigour in the plants (a matter of far greater importance than height), they must be freely exposed to diffused light, otherwise their growth will be weakly and drawn up.

All the further attention that they will now require in the open nursery will be occasional watering, removal of weeds from the beds, and the keeping, by frequent stirring, of the surface open to the action of the air. The tool employed in making the drills will be found to be very convenient for this purpose also.

Roughly speaking, the shade temperature at which Eucalyptus seed germinates most freely varies from 60° to 66° Fahr. by day, and 48° to 54° by night. Under such circumstances the young plants may be expected to show in four or five weeks. All seedlings are both stronger and hardier when raised in a comparatively low temperature.

It is very often advisable, if not absolutely necessary, to prick out the young seedlings at a very early age into baskets, pots, or turves, with a view to the establishing of them later on with greater safety in their permanent quarters. To give a complete idea of this process, and the difficulties that attend its successful accomplishment, it may be interesting to quote from the *Revue des Eaux et Forêts*[1] the practice resorted to at the establishment of Trois Fontaines, where it is held as an axiom that in all climates where the temperature does not fall below 6° or 8° C. (43° to 46° Fah.) the success of the Eucalyptus is assured :—

"A large cold house has been constructed to receive the boxes in which the seed is to be raised. In the climate of Rome a heated house is unnecessary. Frequently, save in exceptionally hard winters, the preparation of the frames is carried out in the open, and the seeds germinate freely even with a temperature of 4° or 5° C. below zero (25° Fah.). All kinds have been tried, and all have succeeded; but at present *E. globulus* and *E. resinifera* prevail both in the seed-beds and plantations."

Any kind of soil, so long as it is in a state of fine division, and provided it is not too hot to injure the delicate seed of the Eucalyptus, is laid in frames of wood thirty inches long, twenty inches wide, and sixteen inches deep, filling them to within two inches of the top. Above this is laid the soil in which the seed is to germinate, which should be, as far as possible, the same as that in which the trees will be subsequently planted. This bed, in which the sowing is to take place, should be well sifted and perfectly even. "The seed should be scattered by hand or with a fine sieve, as evenly as possible. After sowing, another light layer of still finer soil is scattered over the seed, just sufficient to cover it and no more. A light watering is then given, and repeated at intervals until germination takes place."[1]

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[1] *Revue des Eaux et Forêts*, p. 219 (1882).

When the plants have attained a height varying from two and a half to four inches, they are transplanted into smaller frames, which hold only forty plants, and are consequently easily carried. These frames should be prepared in the same manner as the former ones, and the plants should be set in them at intervals of four inches from each other.

The system here practised seems, in the eyes of one accustomed to the simple course of procedure adopted on the Nilgiris, to involve a very great and unnecessary amount of labour and expense, and to show no counterbalancing advantages. It seems hard to understand why plants that endure with so much hardihood the scorching suns, drying winds, and keen frosts of the more exposed portions of the Nilgiri plateau, during the dry season from November to April, should stand in need of such excessive care when planted out in what may fairly be considered more favourable conditions. Want of moisture is evidently not the cause, for the clayey subsoil is said to be fairly permeable, and water is found at from fifteen inches to three feet below the surface.

It would seem indeed that the same results might readily be obtained in climates far more severe than that of Rome, by the use of cold frames either of wood or masonry, well banked along the sides by sods or stable manure.

The burning of the seedlings above alluded to is by no means uncommon in nurseries of far hardier plants than the Eucalypti, and is exhibited almost invariably on that part of the stem which lies between the cotyledons and the collar. It may be attributable to two causes: first, to the direct action of the sun's rays after frost; secondly, to sunstroke, which is usually felt more severely in black soils, owing to increased radiation from the surface of the earth, and is shown at the point of contact with the ground. Both mishaps are equally easily avoided.

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[1] *Revue des Eaux et Forêts*, p. 212 (1882).

Where the successful establishment of each individual plant is a matter of vital importance, a different mode of procedure is adopted at the time of pricking out the young seedlings. The seeds may be raised either in frames or in open nurseries, as may be convenient, but when the young plants have attained the requisite size, they are pricked out singly into small wicker or reed baskets, three or four inches in diameter and twelve or fourteen inches deep. The baskets resemble, in fact, what are known as strawberry pottles. These are filled with the same soil as was used for the frames, in which, when the seedlings are potted off, they may be ranged.

This process is a perfection of the original idea of planting the seedlings in bamboo pots or tubes, which was practised many years ago for filling up the vacancies in young coffee plantations in South-Eastern Wynaad; and that it is still practised in the Government Eucalyptus plantations of South Australia we learn from the Report[1] on the Forest Administration of that colony, where it is stated that "many of the Eucalypti, or Gum plants, have to be raised in the nursery in bamboo tubes, and transplanted, still with the bamboos, into the forest enclosure."

These bamboo tubes are open to serious objections. (1) The bamboo, independently of the thickness of its walls, is covered externally with a vitreous coating of pure silica, capable of withstanding for a long period the action of decomposition, so that the young roots have no means of penetrating into the surrounding soil. The plants thus become pot-bound, and their growth is seriously checked. To obviate this, it was customary to split the bamboo tubes at the time of planting, but this was found to be but a half measure, and wicker baskets, made of thin slips of bamboo, from which the outer glazed covering had been previously removed, came into general use. These have been found to act satisfactorily in every way. (2) In the case of the tubes, decomposition frequently gave rise to the formation of a white fungoid growth, which at times attacked and injured the roots of the plants.

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[1] *Forestry*, January 1884.

In countries where bamboo is not available for this purpose, excellent substitutes may be found in deal shavings, split osiers, reeds, straw, or other similar materials.

Another excellent system by which gum, cinchona, or other plants may with equal readiness be established, is that occasionally practised for the propagation of vines.

A complete covering of tough fibrous turf taken off a sheep-walk, is covered with several inches of fine maiden loam. When the seedlings are about nine inches high, with four or five fine fully-developed leaves, and when their first set of strong quill-like roots begin to interlace with each other, each plant is cut round with a knife, so that it rests in its own bit of isolated turf, and the points of its roots are cut off. They flag a little for a few days, but soon begin to grow again. They are then raised on a square trowel and transplanted in a similar bed of turf and loam, being placed from nine to twelve inches apart, according to their strength.[1]

Although gum seedlings—especially those which are intended to be set out in their permanent quarters so soon as they have attained a moderate height, say eight or ten inches—may be treated in this way, where somewhat larger plants are needed it will be better to resort to the following method:—

Square bricks of turfy loam, say ten inches long by four inches square, should be neatly cut out with a sharp instrument, and laid on end together, either in a frame or in open beds, the soil in which they rest having been previously loosened to the depth of a few inches, and made level. In the centre of each of these sods a hollow, resembling a flower-pot in shape, is scooped out to a depth of six or eight inches, and the space filled up with fine loamy soil. Into this the seedlings should be pricked out and allowed to grow. A fortnight or so before transplanting, each of these sods should be cleanly cut round with a sharp knife and slightly lifted. After a few days, when the plants have fully recovered from their temporary shock and resumed their normal growth, they may be taken up and planted out *in situ*.

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[1] See article by Mr. William Thompson of Clovenfords, in *Journal of Horticulture* for January 18, 1883.

Where young seedlings of any size, say from fifteen to twenty inches, are desired, good-sized basket-pots are decidedly to be preferred.

No pains should be spared, during the earlier stages of the seedlings' progress, to insure stout, short-jointed, vigorous growth. Such seedlings are always those best furnished with fibrous roots, and therefore those most capable of withstanding, and recovering rapidly from, the sudden and severe shock of transplantation. They also subsequently make the most rapid and healthy growth. Weak-drawn plants are especially to be avoided.

When necessary, frequent applications of weak liquid manure will be found of great service in helping on those plants that are deficient in strength or backward in their growth, but these must be applied with discretion, as undue forcing is productive of more harm than good.

FEBRIFUGAL INFLUENCE OF THE EUCALYPTUS.

As the influence of the Eucalyptus in counteracting malaria is perhaps the chief cause of its introduction and cultivation in European climates, it may at this stage be desirable to note the results that have been recorded up to the present time, and also to consider the best system to be followed in planting the trees for this object.

There are many instances in which it has been clearly proved that tracts of land, which were uninhabitable on account of the deadly malaria prevailing, have, in the course of five or six years subsequent to the planting of a few hundred Eucalypti, become perfectly healthy, and capable of supporting a labouring population throughout the whole year. As the lands in question, moreover, have not been allowed to lie waste on account of the poverty of their soil, but are, in the majority of cases, of unusual fertility, and capable of producing a great variety of crops in marked abundance, the necessity of reclamation is all the more urgent.

The results already obtained at the establishment of Trois

Fontaines are worth quoting. The land was granted to the Trappist Fathers in 1870, "when seed was scarce and the Fathers were poor," but by the time they had contrived to plant one hectare (2½ acres), and after the young Eucalypti had reached the age of five years, a perceptible amelioration showed itself in the sanitation of the colony. "During the earlier years of their residence twelve of their number had succumbed to fever, and it was only in 1874 that permanent residence became practicable;" but gradually the improvement advanced, and in 1882 the sanitary condition of the establishment was considered perfect, "in spite of the hardness of the living."

According to M. Meaume, the planting of Eucalypti with agricultural crops "gives wonderful results." The health-giving power of the febrifugal tree is so great that it is not necessary to plant it in solid blocks, the desired result being obtained by setting it in lines, allowing 360 trees to the acre. The seedlings may be set out in single, or in double rows, or in a quincunx manner, and immediately afterwards wheat, maize, rye, barley, or oats, may be sown between.

For sanitary purposes it is clear that one of the chief objects to be aimed at is the distribution of the trees as evenly as possible, but in sufficient numbers, over the widest possible area, and as the purifying property of the tree is in direct proportion to the leaf-surface it presents to the atmosphere the course of treatment adopted, both in planting and training, must differ very materially from that which would be followed were they to be grown solely on account of their timber. The number given above, viz. 360 per acre, is no doubt somewhat excessive, save in the most deadly localities, and so many trees, when they come to any size, would seriously hamper the production of other crops on the same ground. Those best acquainted with their cultivation are aware that when once they are established, and their regular habit of growth assured, they are less inclined than almost any other forest tree to spread out and make free lateral growth. The only means of inducing them to do so to any extent is by giving them free space. The symmetry of the tree and the value of its timber are undoubtedly affected by this course, but its power to neutralise malarious influence is much enhanced.

As in the case of Coniferæ, at all stages of their growth, the young lateral branches should on no account be pruned or cut off, as they will of themselves die and fall off when their term of growth is over; nor, on the other hand, is it advisable to endeavour to induce a more bushy growth by removal of their leader, inasmuch as they immediately form a new leader, and divert so much sap to its nourishment that no permanent result can be obtained.

"Malarial fever rages in Corsica with exceptional frequency and severity. Every year the entire population of the eastern coast of the island is obliged to desert the shore for the mountains to be out of the reach of the pest. This exodus takes place towards the end of June, and only on the approach of winter do the inhabitants venture to return to their dwellings. An attempt at Eucalyptus-planting has been successfully made at Bastia for the sanitation of a forest lodge. This lodge, which is designed for a residence for three of the forest guards, is situated at a rather high level in the valley of Fango, in a locality called Birio. It stands in the midst of a forest of evergreen oaks and maritime pines, and every year was visited so severely by fever that the families of the keepers were obliged to seek refuge at another spot. The Inspector of Forests undertook to surround the lodge with a screen of Eucalypti, set thickly on the windward side. As soon as the plants had attained a fair size, that is in five or six years, the fever disappeared altogether, and the families were able to return."

In the hill districts of Southern India the same febrifugal influence of the Eucalyptus is well known.

A few trees that were planted round the Cooly lines of estates situated within the fever range speedily corrected the unhealthiness of the site, and the isolated cases of fever that occurred subsequently were attributable to infection taken elsewhere, or to latent germs brought into action by constitutional derangement. The sanitation of the lower portion of the hill station of Coonoor, which is also within the fever range, and which embraces a very malarious mountain gorge, has become sensibly improved since the few hundreds of Eucalypti, planted as ornamental or avenue trees, have attained timber size, and the same remarks will apply to other parts of the Nilgiris where Eucalyptus cultivation has been carried out to any extent.

It is important, in the planting of febrifugal Eucalypti, carefully to note the direction of the prevailing winds of the locality, as these drive the malaria before them. Thus in Italy, Southern France, and Corsica, the disease is generally blown inland from the seashore; on this windward side greater protection is necessary, and more trees should be placed here than on the leeward margin.

Wherever these trees are planted as a protection against malaria, the external line should be from three to five rows deep, and planted in quincunx form; the next three or four lines may be double or single quincunx, after which single rows will probably be found to suffice. Free room should be allowed to each plant, and a distance varying from nine to fourteen feet in the lines will not at the outset be found too much.

Again, since malaria, though seldom or never rising above sixteen feet from the ground, ascends the hill-sides parallel to the slope for a considerable distance, the cultivation of these trees may be carried to a considerable elevation. At the same time, by widening the intervals left between the lines as far as practicable, the intermediate cultivation of cereals, vines, pulses, and other produce is rendered more easy. For such purposes the natural habit of the tree is specially adapted; not only is it deep-rooting, defying with impunity the fiercest gales of wind, but its pyramidal form and the lightness of its foliage render its shade far less injurious than that of any other tree, and grasses, grain or other crops, may be seen growing luxuriantly up to its very stem. In proof of its power of resisting storms, it may be recorded that on the Nilgiris, during the two memorable cyclones that occurred during the month of May in the years 1872 and 1874, when hundreds of trees of all descriptions were torn up by the roots, several Eucalypti that were exposed to the full fury of the storm were steadily watched, and, though tempesttossed and bent like blades of grass by the terrific gusts of wind, their hold on the soil was never shaken, so that, when the gale ceased, they stood as upright as they had done at its commencement.

In conclusion, it may be noted that although the power which the Eucalypti possess of drying up, in a short space of time, large tracts of stagnant marsh lands, has been somewhat exaggerated, still, once they become established, and if the work has been undertaken in a progressive manner commencing from the outside and gradually working inwards, very astonishing results may be obtained as soon as their action on the soil has set in. Where the water-supply of a town or station is scanty, and carried in open channels, they are unsafe subjects to plant along the banks, as the immense power of the roots to absorb, and of the leaves to evaporate, will, if the trees exist in any numbers, prove to be a severe strain on the available supply. This was found to be the case to such an extent along the water-channel upon which the supply of the town of Coonoor depended, that the order had to be given, though reluctantly, to cut down a considerable number of fine trees that were scattered along its course.

TRANSPLANTATION AND MAINTENANCE.

The following short description, given by M. Meaume,[1] relative to the procedure followed at Trois Fontaines, may be found of interest :—

"For planting in single lines, trenches thirty-two inches wide and the same in depth are constructed. If the lines are to be double, *i.e.* to contain two rows of young trees, they are made six feet wide and thirty-two inches deep. In this case the trees are planted in quincunx, allowing a distance between them of one and two metres. It is important that the seedlings should be turned out of the frames on the spot, with a sort of trowel, immediately before planting, so as to preserve their tender roots, and, if these project beyond the ball of earth, they are cut. They are then planted, a hollow depression being left round each seedling.

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[1] *Revue des Eaux et Forêts*, p. 209.

"For the first five months watering is required during the great heats, to the extent of eight or ten litres of water per plant at least once in every eight days. This involves a considerable expense, but success can only be bought at this price."

The system of transplanting here followed is but another proof of the extreme pains that are taken at this establishment; but considering that most of their work is done by convicts, they are placed under exceptionally favoured circumstances, and in possession of ways and means that would not be available to others who purposed to plant Eucalypti on a large scale and at a minimum of cost. That there is frequently a very great mortality in European plantations during the first two or three years following on transplantation, and that great pains are necessary to insure success, may be gathered from the report on the experiment made at Bastia, where it is stated that "the 500 trees now surrounding the lodge are the only survivors of 1200 planted. The cost of planting was 1000 francs, amounting to two francs for each surviving tree." This excessive cost would doubtless prevent the afforestation of Eucalypti on an extensive scale, but in any climate that is capable of supporting them no such expense is necessary.

On the Nilgiris, where, as a rule, the most perfect weather for transplanting purposes prevails at the commencement of each monsoon, they can be put out with the same ease as tea or coffee plants, and with the certainty of there being but few blanks if the work has been executed with ordinary care. When, however, they must be planted at other seasons, or during uncertain weather, the utmost care is necessary at all stages of the work, so that they may not remain stationary or "sulk" for one or two years before making a fair start into growth,—the young and tender rootlets being easily injured, and requiring some time to recover from any shock. Plants raised in basket-pots or turfy loam, taken up with a fair ball of earth attached to their roots, may be planted with impunity at almost any season. In certain cases the method of transplanting twice in the nursery previously to the final planting out may be found an excellent and economical one.

The true cause of the difficulty in transplantation is not far to seek. All foresters are aware that those trees whose nature it is to develop abnormal tap-roots throw out comparatively few lateral fibrous rootlets, and as facility of transplantation depends chiefly on the presence of the latter in a healthy entire condition, tap-rooting plants invariably require careful treatment. It is with this object that young forest-tree seedlings usually undergo one, if not two, transplantations in the nursery previous to their removal to their forest homes. At all times, however, this operation causes more or less of a shock to the constitution of the seedling, and acts as a certain check in its growth for the first few years, while the careful pricking out of the young plants into baskets or pots at a very early age is hardly felt, and in subsequent transplantation no check is given to them. In the case of planting from an open nursery, seedlings possessing from six to eight pairs of leaves will be found to shift most readily.[1]

So far as data would lead one to judge, in our latitudes autumn-planting is to be recommended. The frequent rains that prevail at this season, and until spring has fairly set in, greatly stimulate the production of healthy roots, and assist the plants in taking a hold of the ground. A sufficient protection against any undue severity of frost may be obtained by piling a light litter of ferns, straw, or other material loosely around the stems, and, during the first season, round the apices of the plants. The extent to which Eucalyptus seedlings have stood with impunity, at Trois Fontaines and elsewhere, several degrees Centigrade of frost, clearly shows that it needs but ordinary care to enable them to arrive at that stage at which they will in similar climates be virtually proof against all further danger of this kind.

"Except in the case of planting in soils like turf, in which the roots remain entire, it is undesirable that the operation should be done while vegetation is still active. During the remainder of the year it is evident that the season of frosts is highly unfavourable. There is therefore no choice left but between autumn and spring. If it be remembered that the welfare of plants *depends on the state of the roots*, it is at once seen that autumn is preferable to spring. The drought which follows the vernal equinox exposes the roots to the danger of drying up rapidly. Now the finest extremities of the roots constitute the organs of absorption, and their entirety is the first condition of success. Moreover, in the case of seedlings not very young, the alternation of frost and rain which usually characterises the close of the season of vegetation, produces complete contact between the roots and the soil. But, on the other hand, when the seedlings are put out quite young, frost, by causing the soil to expand, compels them to follow the upward movement, and when thaw sets in the young plants run the danger of having their roots laid bare. It cannot therefore be laid down as an invariable dictum that autumn is preferable to spring, or *vice versa. The essential thing is to plant carefully.*"[1]

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[1] In the case of seedlings sown in drills, the tap-roots may be cut *in situ* by a spade specially designed for the purpose, and transplanted after the following season's growth.

The severity of the frosts likely to occur in climates where the planting of Eucalyptus is practicable to any extent, is not likely to be sufficient to cause any injury by the upheaval of the ground, provided that the transplantation has been effected somewhat early in autumn; consequently planting at this season will give decidedly the best results.

The pits into which the seedlings are set ought to be deep enough to enable the plants, with all their roots, to be put into the ground with perfect freedom, and as low down as they were before. A greater depth is unnecessary, as the tap-root will always find its way down, but a freer margin must be allowed laterally for the production of the fibrous rootlets, which first provide nourishment for the seedling, and on the growth of which its future chiefly depends. In making the soil firm after planting "too great pressure is to be avoided, as complete contact is a question of time. . . . It is always advisable to place flat stones round each plant; these preserve the moisture of the soil, and prevent it from swelling too readily during frosts."[2]

Where stones are not procurable, any litter or mulching will have the same effect. It is an important point in all transplanting that the seedling should be inserted just up to the collar, or very little further in light soils, in order to allow for subsidence.

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[1] *Elements of Sylviculture.* By M. Bagneris, p. 225.

[2] M. Bagneris, *loc. cit.*

It is well known that artificial waterings, however copious they may be, never exert the same influence on plant growth as is caused by a very much less volume of water falling in the form of rain; and that the moisture so supplied is evaporated much more speedily. The covering of the soil in the immediate neighbourhood of the stems with litter of any sort serves in a great measure to keep the surface fresh, and where the plantation is not on too extensive a scale, should always be resorted to. The practice of opening out a trench, and thoroughly "making" the soil therein contained, previous to the insertion of the plants, is an excellent one, and owing to the greater ease with which it can be performed, it is not appreciably more expensive than the ordinary practice of pitting. At the same time, the dimensions given to the trenches at Trois Fontaines seem to be somewhat excessive, and to involve much unnecessary labour and expense. On the Nilgiris cylindrical pits eighteen inches in diameter have given the best results that could be hoped for. In hard soils, and where extra care is necessary, the pits may be made two feet in diameter and the same in depth, but there should in no case be any necessity for exceeding this limit. One of the reasons for the formation of excessively deep trenches at Trois Fontaines may be the fact that the soil is in parts underlaid by an impermeable bed of volcanic substance, there termed "cappellaccio." This is so hard as to necessitate the use of dynamite to break it up, and where it or tufa prevails to any extent, its breaking up becomes a necessity. In the case of planting large tracts of land the pit system is decidedly to be preferred.

The method of setting the plants in a shallow depression is an excellent one where much heavy watering has to be done, but the surface should be stirred from time to time, and never allowed to cake. It may be advisable to fasten the young plants to stakes for the first two or three years of their growth, more especially on the outside of the block, or when they are planted in shallow lines in exposed situations, though this may seldom be found necessary.

Viewing the Eucalypti from the forester's standpoint, it is to be noted that, save on the Nilgiri Hills, afforestation has only been carried out to any extent in the plantations belonging to the French Government in Algeria, and the success of the results that have been there obtained may be gathered from a report by Dr. Howitz.[1]

It is manifest that in the formation of forests the same great care and attention cannot be given to each individual plant as is the case with seedlings in a nursery, or where only a few hundreds have to be dealt with. The treatment must be much more general, and conducted with regard not only to present needs, but also to economical working in the future. In European climates, it must, under any circumstances, always be more costly than that of planting out the ordinary indigenous woods; yet, by the judicious choice of varieties, by the selection of the proper season for the performance of each detail of the work, and by the exercise of skilful management as the trees develop, the returns will be very much greater, and amply compensate for the expenditure incurred. The rapidity of their growth, the greater value of the thinnings as well as of the timber when the trees have attained maturity, render the planting of Eucalypti far more remunerative than that of any other tree, apart from the influence exercised by them on the rainfall and climate.

On the whole, save in the case of lines for shelter or febrifugal effect, quincunx planting cannot be recommended. It is more troublesome, less likely to be done with regularity by unskilled workmen, and later on obstructs the circulation of a free current of air, which is a most important consideration in damp ground where large numbers of trees are grouped together. Moreover, later on, it renders the subsequent operations of thinning and working less easy.

With reference to the distances at which the trees in the permanent plantations should stand from one another, my experience fully coincides with the views expressed in the report to the Government of India on the Nilgiri plantations, and with those of Dr. Howitz on those in Algeria, viz. that for planting as continuous forest six feet apart each way is the most suitable distance at which Eucalyptus can be placed, and that seven feet is the widest limit to be chosen under exceptional circumstances. There are two considerations in favour of close planting: (1) the tendency of the Eucalyptus to lose its upright habit, unless constrained by the pressure of surrounding trees; and (2) the more than usual necessity for the preservation of a leaf canopy in the case of trees whose foliage is at the best so very scanty (far more so than that of the oak), especially considering the liability of exposure to prolonged and severe droughts in those countries in which it is found to succeed best. At the same time it must be remembered that the natural development of the upper portions of the tree are out of all proportion to the rapid and massive growth of its stem, and that therefore a certain scope for lateral growth must be allowed to each individual.

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[1] *Revue des Eaux et Forêts*, p. 505 (1882).

With reference to the plantations existing on the Nilgiri Hills in 1876, the Conservator's remarks bearing on the desirability of close planting in the afforestation of land are of much interest and importance. His report[1] is as follows:—

"Norwood Plantation is one and a half miles from Ootacamund. Twenty-six acres were planted in 1872 and 1873, nine feet apart each way, with 14,000 *Eucalyptus globulus.* The stems are more or less crooked, from being planted too far apart, but the growth is good for a fuel plantation. It should give at least 100 tons to the acre, and produce again from the stools. It is reserved as an accessory to Government House.

"Cally Plantation is three and a half miles distant from Ootacamund. Fourteen acres were planted six feet apart each way in 1870 with *Eucalyptus globulus;* when two years old, in 1872, it was burnt down by a fire which crept in from the grass lands adjoining. It has, however, made splendid growth from the stool, and having been pruned down to one leader, no one without very close examination could detect that the trees were not the original seedlings."

This ability on the part of the Eucalyptus to withstand and recover from so serious an injury as the above is another argument in favour of its cultivation as a forest tree: more especially when we consider that in most of the countries in which it is found to succeed, jungle fires, arising from the spring burning of the surrounding grazing lands, are always more or less to be apprehended, and with most other crops would result in irretrievable disaster. The report then proceeds:—

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[1] *Manual of the Nilgiri District*, p. 444.

"Baikie Plantation is three miles from Ootacamund. Thirty-three acres were planted in 1874 with 39,000 *Eucalyptus globulus* at six feet by six apart. Growing well.

"The Newman Plantation is about five miles from Wellington, and covers thirty-five acres, of which twenty-five were Shola (*i.e.* natural wood), and ten grass land. It was planted in 1870 and 1871 with *Eucalyptus globulus*, six feet by six apart, and there are about 40,000 trees, and the growth is certainly splendid, and beyond anything I have ever seen in any country.

"Rallia Plantation is four or five miles from Wellington. Sixty acres were planted in 1872 with *Eucalyptus globulus* and *Acacia melanoxylon* alternately in broad strips. The growth of the Eucalyptus is not straight."

"The Old Forest Plantation is situated about three miles from Wellington. Two hundred acres were planted in 1872-73, nine feet apart each way, with *Eucalyptus globulus*. This is the best soil and aspect of any of the plantations, and would have been a magnificent plantation if it had been planted closer; the trees having grown very crooked. The growth has been exceedingly rapid, the average height being 59¼ feet, and the average girth 17½ inches, and although there are only 537 trees to the acre, the weight per acre (exclusive of tops and branches, which average 70 lbs. per tree) was computed at 39 tons."

Dr. Howitz's experiences in Algeria point equally clearly to the necessity of close planting in all cases in which the tree is to be grown for the ultimate value of its timber. He says:—

"At Bechuen orders were laid down that the trees (*E. rostrata*) should stand three metres from each other both ways. Fortunately the foresters exceeded their instructions, and planted a portion only two metres apart. As a consequence, this section not only shows the best growth, but has not lost a single plant, whereas the remainder is weak and scrubby."[1]

It may then safely be laid down that six feet by six is the proper distance at which to set out Eucalypti in general forest cultivation. If closer, the plants have a tendency to run up in a weakly and drawn manner, and thinning becomes necessary before the wood has attained a fair market value. If, on the other hand, they are planted further apart, the straight growth of the trees will be affected, and the value of their timber materially reduced.

Finally, it may be noted that Eucalyptus trees should be planted, not in conjunction with other woods, but by themselves. No other tree can compete with them in the struggle for growth. In the Rallia Plantation an attempt was made to grow them alternately with *Acacia melanoxylon* (a rapid grower, but a very useless and unsatisfactory forest tree), but with the result that the straight growth of the Eucalyptus was seriously interfered with.

It by no means follows, however, that several kinds of Eucalyptus may not be grown together, provided that the rate of growth of the varieties so mixed is tolerably even, and that no single variety can, by taking possession of the soil, overshadow and crush its weaker neighbour. A very excellent plan would be to lay down a forest with three-fourths or four-fifths of *Eucalyptus globulus*, and the remainder with the more rapidly growing Red Gums and Ironbarks that are chiefly remarkable for the quality of their timber. During the first five or six years the presence of the former would cause the latter to send up clean, straight, sound stems, and when the growth began to get hampered, the Blue Gums might be treated as coppice, while the latter would grow on to full timber dimensions. Such a system would be by far the most profitable manner of laying down woods of Eucalyptus, and in suitable localities, whether undertaken by the State or by private enterprise, could not fail to prove a highly remunerative investment for capital.

A few words may be added with regard to the care that must be taken of seedlings during the first few years after transplantation. The costly system of watering that is said to be a necessity at Trois Fontaines seems to be chiefly due (1) to spring planting, and (2) to the fact that the seedlings are not put out in baskets or pieces of turf. The young plants, it is true, should not be allowed to flag to any serious extent, but should, whenever practicable, receive a good soaking at the time of planting out, to be followed by another, if necessary, at the end of a week. But beyond this, all nurserymen and gardeners are aware that when once one has begun to nurse young plants by the constant use of the waterpot, one must keep on doing so, and their hardihood is seriously diminished. Hence, except in cases of extreme danger, it is better to harden them off than to keep on nursing them with constant sprinklings. They will come on all the faster, and make better growth when timely rains arrive.

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[1] *Revue des Eaux et Forêts*, p. 507 (1882).

For the first two years the ground should be kept free of weeds, when practicable, for a certain distance round their stems; after which, if they have been planted close enough, they will be fully capable of taking care of themselves, and will soon kill down any herbaceous growth that may remain under their cover. As previously observed, no cutting or pruning of any sort is required, save such as may be actually necessary to insure straight growth, or to turn the flow of sap from too luxuriant lateral shoots.

MANAGEMENT OF EUCALYPTUS PLANTATIONS.

Before expressing my own views as to the way in which Eucalyptus plantations may be most profitably worked, extracts from those parts of the reports of the Conservator of the Nilgiri Forests, and of Dr. Howitz, that deal with the quantity and value of their produce, may prove of interest. The former speaks as follows:[1]—

"The enormous yield per acre in the Eucalyptus plantations on the plateau between an elevation of 5000 and 7000 feet elevation is very astonishing. I calculate it as about 1450 cubic feet per acre per annum for the first five or six years, or in dry weight 25 tons per acre per annum (=58 cubic feet to the ton).

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[1] *Manual of the Nilgiri District*, p. 446.

The Eucalyptus grows splendidly from coppice, and five or six years would appear to be the best period for rotation, so that a permanent supply of about 25 tons per acre per annum may be calculated on.

"I deputed Mr. Gass (trained forest assistant) to make very careful calculations in the Newman Plantations near Wellington, and the following was the result:—It was found that 292 trees were standing on 10,890 square feet (*i.e.* one-fourth of an acre). The measurements taken were as follows:—Average height deduced from six trees 69 feet; average girth deduced from ten trees 19 inches. Three trees were felled, respectively 28, 20, and 12 inches in girth; the first contained 13½, the second 7½, and the third 2 cubic feet (the upper part of the stem, where less than 3 inches in diameter, was not reckoned). This gives an average cubic extent of 7⅔ feet to each tree, or (multiplying by 292 and dividing by 58) 38 tons to the quarter acre; that is, 152 tons per acre. The tops of the three felled trees, together with the branches, weighed 170, 100, and 80 lbs. respectively (average, 116 lbs. per tree). This, however, was not added in the calculation given above, as the weight of the green wood gives very erroneous results, the wood having been proved to lose about two-fifths of its weight in six months. The first tree felled, which was measured to be 13½ cubic feet, was weighed, and found to be 880 lbs., whereas its dry weight would only be about 500 lbs., or between 38 and 39 lbs. per cubic foot.

"In the plains we only calculate for $2\frac{6}{7}$ tons per acre per annum from Nahool and other plantations, so that the rate of growth of the Eucalyptus up here may be said to be nine times as rapid as anything we can grow in the plains. Our fenced-in fuel reserves of indigenous trees in the plains are, as I have reported, only yielding one ton per acre per annum, but they may be worked up to a much greater yield, and cannot, of course, in their present state, be compared with regular plantations.

"Mr. Gass at my request also made careful measurements of some of the largest trees in the Aramby Plantations (now twelve or thirteen years old). Fifteen trees were measured with the following results:—Average circumference, 34 inches; height, 85 feet; average cubical contents, 23 feet. The bole decreases to less than one foot in girth at about 14 or 15 feet from the top.

"Although there are many trees in this plantation averaging 23 cubic feet, there are many that are mere spindles (the result of too little and injudicious thinning), and if now cut over, the yield would not be more than 150 tons to the acre, the same as that calculated for the Newman Plantation at Wellington, which is only half its age. It is true that thinnings have been removed from time to time, but allowing for this, it is clear that the best period for Eucalyptus as a coppice fuel plantation is about the age of five to six years, according to circumstances. The growth at Wellington is rather more rapid than at Ootacamund, as there is less frost during the winter months, and the plantations can be cut over at five, or even four years of age, but at Ootacamund six to seven years will probably be found the best period of rotation."

Dr. Howitz tells us, first on the authority of M. le Sueur, Vice-President of the General Assembly at Constantine, that Eucalypti grown close, and of six years of age, have been successfully used by him both as props for mines and as railway-sleepers, but under the most favourable circumstances nine years is the earliest at which these trees should be cut, and to use them much earlier (save the necessary thinnings) is bad economy.

Dr. Howitz concludes the first part of his paper as follows:[1]

"Take for example a forest of Red Gums, *Eucalyptus rostrata*, situated in a plain suited to their growth.

"The trees are at a distance from each other of 2 metres (2500 plants to the hectare = 1000 to the acre). At the expiration of six years half the stems had been cut or had perished in the cover. At twenty years the half of those that remained had been sold in their turn, leaving in the ground 625 trees, which at the age of thirty years furnished each of them six or eight sleepers in addition to telegraph posts, etc.,—the whole of a market value of thirty to forty francs per tree. The value of a hectare of forest would be therefore at this age from 19,000 to 25,000 francs (£760 to £1000), which gives the mean annual yield, including the outturn of thinnings, at about 1100 francs per hectare (£17, 12s. per acre). It may here be stated that the prices given are low, and that the period of revolution of the Red Gum has been fixed at only thirty years; whereas, from its thirtieth to its fiftieth year, its produce increases vastly in value. I had before my eyes many similar estimates, procured with the utmost care, the majority of which give a greater annual yield,—a higher total, but show lower rates. Moreover, in Algeria, the distances from the markets are not so great that we could venture to fix any higher prices than those given above."

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[1] *Revue des Eaux et Forêts*, p. 510 (1882).

Granting, then, the immense superiority of the Eucalyptus, both in the quantity and value of its produce, over that of all other forest trees with which we are acquainted, the chief point now is to determine by what system of working the greatest results can be obtained. Save in the last-named instance, Eucalyptus plantations have not been worked hitherto with a view to their producing timber of first-class dimensions, and the period of revolution has been fixed at one-half the time that should have been allowed to obtain the heaviest output. The Nilgiri plantations have been formed and worked so far solely as fuel plantations, and save in the matter of growth and yield, under these conditions give but few reliable data on which to base our calculations. In many ways this is a matter for regret, for nowhere is good sound timber suited for building purposes and indoor carpentry more in demand or dearer than on the Nilgiris. The Madras Government have, however, since the publication of the above-quoted report, instructed the Conservator to preserve and care for all the best trees that are likely to produce good timber; but it does not appear that any organised system of working has been recommended for adoption.

In Algeria the reverse seems to hold, and the varieties that are the most esteemed for the quality of their wood have received quite as much attention as the more widely known Blue Gum.

Before laying down any fixed rules as to the system on which a plantation should be managed, it will be as well first to consider to what ends its produce is to be devoted, and to regulate the period of revolution accordingly. The objects aimed at may be the production of first-class timber, or of timber and fuel combined, or of fuel only. In each of these cases a different course of treatment will be required. With regard to the treatment of extensive virgin forests, in their natural state of growth, it is only necessary to say that where the work has to be undertaken on a very extended scale, the system known as that of *jardinage* or *selection*, will probably be found to be the most convenient at the outset.

If the plantation is to be wrought for timber only, the system of *high forest* is undoubtedly the best, and the period of revolution should not be fixed at less than fifty years; while in cases where the trees are likely to remain in health and maintain vigorous growth, at not less than sixty or seventy years. If the object in view be the production of timber and fuel, or timber and second-class wood (such as would be useful for railway-sleepers, telegraph posts, mining props, etc.), the system known as *Taillis sous futaie* or *coppice under high wood*, will be the best, and may perhaps in European climates be found more generally useful than any other. In this the period of revolution allowed to the coppice will depend upon the purpose for which the wood is required. For simple fuel, six or seven years; for second-class timber, from nine to fourteen, or in some cases even more, will suffice. On the other hand, where a constant and permanent supply of fuel is needed, the practice carried out in the Nilgiri plantations, or a modification of it, will probably answer best, though its profits will not be so great as that of the *Taillis sous futaie*.

One of the most remarkable features of the Eucalyptus lies in the facility with which it springs up from the stool, even in cases where large timber trees have been felled; and the secondary growth will be found in no way inferior to that of the original stem. The only other forest tree that shares this peculiarity to the same extent is the Teak (*Tectona grandis*), of which in the Nillumbur and Mudumally forests of the Wainâd, trees of first-class timber dimensions that had been cut down have reproduced from the stools stems as large as their predecessors. At first the suckers are apt to push in undue numbers, but as soon as a single one has taken a clear lead of the others, the latter may be torn off, and the former allowed to develop.

In the management of Eucalyptus plantations the preferable systems are those of high forest and of *Taillis sous futaie.*[1]

For our present purpose the two systems may be considered together. The first point to be thought of is the time at which the first thinning of every alternate tree must be made This will depend upon a variety of circumstances—the rapidity. as well as the evenness of the growth of the trees, their pressure upon one another, and the probable market value of the produce. In the case of *high forests* especially, the preservation of a leaf-canopy is a matter of more importance in the case of Eucalypti than in that of ordinary forest trees; therefore, so long as the plants are not becoming unduly drawn the longer they can be left to grow the more valuable will be their produce. On this account, save under exceptional circumstances, the first thinning should be deferred until the trees are at least six years old, and where it can be done with safety, they should be left until the seventh or eighth year. By this time the thinnings will have attained sufficient dimensions to be of some value as poles, mining props, etc., as well as for fuel.

By carrying out the first thinning with judgment, a much longer period may be allowed to elapse before the second becomes necessary; and in this instance again the value and volume of the produce is much enhanced by every year that is given to the trees to perfect their growth and consolidate their heart-wood. This will probably carry us, according to their development, to the twelfth or fifteenth year from their transplantation. After this second thinning it may be observed whether the trees shed freely mature and fertile seeds, and whether the process of natural reproduction can eventually be resorted to. The Red Gums and Ironbarks produce mature seeds freely at a comparatively early age, but on the Nilgiris it is at least fifteen years before the germination of the seeds produced by *E. globulus* can be relied on to any extent. The ground in the immediate neighbourhood of thirteen-year old trees that had flowered freely, ripened, and shed their capsules, often shows no signs of the natural reproduction; and it is probable that, as in the case of *Pinus sylvestris*, and most other forest trees, the parent trees from which a supply of seed is to be derived should have attained an age of at least forty years, and should be in the prime of their health and vigour.

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[1] A very clear description of the processes will be found in M. Bagneris' very valuable work on the *Elements of Sylviculture* (translated by Messrs. Fernandez and Smythies).

It is to be noted that the sawn timber of the tree is seldom sufficiently matured for building purposes, planks, or other uses, until it has attained an age of at least fifteen years, as the heart-wood takes a considerable time to consolidate and harden. It is on this ground chiefly that the second thinning should be deferred as long as possible.

From this time probably at least from ten to fifteen years may be allowed to elapse before a third and final thinning will become necessary; and then the period will have arrived to consider whether the forest is to be maintained by *coups de régénération* or by shoots from the parent stems, the latter method being probably the better.

Dr. Howitz, referring to the quality of the wood of the Eucalypti, says that "it has been often asserted that the wood of the Eucalyptus is inferior to that of the oak, on the score of its warping, cracking, and splitting badly. This hardly seems to be just, applying as it does to the wood of the first revolution, which is always inferior to that of the succeeding ones, apart from the consideration of the relative merits of different species. It is necessary, too, for a fair comparison to be made, that the wood of a tree that grows with the rapidity of the Eucalyptus should either be soaked in water or charged with steam previous to its being put into use. In Australia, railway-sleepers made of the wood of the Blue Gum are calculated to last over nine years; but this refers to the timber of mature trees, and not to rapidly-grown young saplings, as used in Algeria. Probably the duration of the wood, more especially in the case of that taken from young plantations, would be much increased if they were well soaked with creosote previous to being laid down."

The growth of the trees, as observed at Hyères and other places along the coast of the Riviera, though hardly so rapid as that of the better plantations on the Nilgiris, seems to be in all respects satisfactory,—at all events, so far as the Blue Gum and *Eucalyptus resinifera* are concerned, but some of the ornamental and fancy varieties are probably less at their ease in the change of soil and climate. Nevertheless, all those that have been recommended above will be found to make good growth and to yield valuable timber.

Where it is decided to establish plantations for the supply of fuel only, the course adopted by the Madras Government in their Nilgiri plantations is not susceptible of much improvement, but seven years at least should be allowed as the period of rotation.

It has been fancied by some that the seed of trees grown at Bordeaux, and other similar localities, where the extreme of climate suited to their cultivation seems to have been reached, are more capable of withstanding occasional severe frost than those raised from Australian seed. Although, in the course of time, after several generations of mature trees have passed away, and have been reproduced from seed, it is no doubt true that certain constitutional changes may develop; still, at present the preference must be given to imported seed that has been gathered from healthy old trees.

XI.

THE PRESENT AND PROSPECTIVE SOURCES OF THE TIMBER SUPPLIES OF GREAT BRITAIN AND IRELAND.

By Robert Carrick, *Gefle, Sweden.*

In the handling of this comprehensive subject it is proposed to deal only with those countries from which the exportation of wood to Britain is most extensively carried on—that portion of the question relating to the *rôle* which the forests of the British Isles themselves play at present, or may be expected to play in the future, towards supplying the ever-increasing demands of this country for timber, being left out of consideration.

The table on the following page gives the Board of Trade statistics of wood imports into Great Britain for the last eleven years.

In studying this table it is to be noted that, while the import of unmanufactured timber has been practically stationary for the last decade, that of sawn or manufactured wood shows an increase of above 900,000 loads; and it is further to be observed that while in 1873 the ratio of imported unmanufactured wood to sawn timber was as 10 to 17, during the past year the quantity of the latter was more than double that of the former, and by contrasting a still earlier period with the present, the change would be found to be still more marked.

These statistics moreover reveal to us the countries from which the greater part of our timber supplies is derived, viz., Sweden and Norway, Russia, British North America, Germany, and the United States. It is true, indeed, that a considerable amount of teak is imported from British India and Burmah, as well as of mahogany and other fine woods from Mexico and

IMPORT OF WOOD GOODS TO GREAT BRITAIN FROM 1873 TO 1883 INCLUSIVE.

	Year Ending 31st December, and Quantity in Loads.										
	1873.	1874.	1875.	1876.	1877.	1878.	1879.	1880.	1881.	1882.	1883.
Hewn timber from											
Russia, ...	340,702	496,732	293,290	327,429	374,011	322,219	174,898	336,649	229,914	299,588	280,490
Sweden and Norway, .	700,097	622,810	437,206	612,768	532,000	468,096	436,653	658,881	600,002	609,187	630,041
Germany, ...	262,818	299,434	224,549	257,067	204,757	216,158	200,911	277,579	224,205	297,031	350,243
United States, . . .	...	...	...	...	...	...	...	...	...	155,422	111,285
British India, ...	...	...	...	...	...	...	...	...	...	39,918	41,531
British North America,	365,875	476,375	336,867	470,949	485,720	260,890	196,431	360,622	298,514	277,745	336,184
All other countries, . .	401,898	552,043	396,027	490,082	483,125	413,442	369,322	486,143	513,664	339,516	392,831
Total, . . .	2,071,390	2,447,394	1,687,939	2,158,295	2,079,613	1,680,805	1,378,215	2,119,874	1,866,299	2,018,407	2,142,605
Sawn, planed, or dressed timber from											
Russia, ...	754,666	937,643	842,864	1,004,786	1,171,001	914,807	723,609	1,060,608	930,136	1,178,318	1,075,574
Sweden and Norway, .	1,535,852	1,520,526	1,264,876	1,659,104	1,771,002	1,453,477	1,406,630	1,608,201	1,422,470	1,652,933	1,717,072
British North America, .	954,356	1,076,188	953,228	1,107,347	1,256,212	963,171	904,589	1,147,040	994,149	1,010,413	1,181,606
All other countries, . .	170,849	270,890	236,862	331,381	374,533	287,641	218,484	271,055	322,092	335,096	339,381
Total, . . .	3,415,723	3,805,247	3,297,830	4,102,618	4,572,748	3,619,096	3,253,312	4,086,904	3,668,847	4,176,760	4,313,633
Staves—all kinds, . . .	86,438	124,341	92,522	129,424	116,670	88,257	84,970	103,253	118,664	125,696	141,189
Mahogany, ...	52,343	65,011	80,409	52,317	53,163	43,623	44,969	41,119	42,214	36,004	49,784
Grand total, . . .	5,625,894	6,441,993	5,158,700	6,442,654	6,822,194	5,431,781	4,761,466	6,206,788	5,535,146	6,195,167	6,456,238

the neighbouring States of Tropical America, but these supplies—although of prime importance for the furnishing of our homes, and the fitting out of our steamers—do not constitute a large proportion of the entire import of wood, and it is only necessary to point out in connection with them that since great attention is now being paid to the reproduction of these woods, not only by the Indian Forest Department, but also by the Mexican Government and others, our demands for such hardwoods are not likely to fail to be fulfilled in the immediate future.

It is here proposed to consider the above-named territories in the order of their importance from a timber-exporting point of view, as well as the growth of our import trade, and the probability of an increase or decrease in our future supplies from each.

SWEDEN AND NORWAY.

Notwithstanding the fact that these countries have the same ruler, and are confederated in so far as their representation abroad and their defence at home are concerned, they are in all essential economic respects distinct, and ought to be treated separately in the Board of Trade Returns of timber import, if the latter are to be rendered of value to British timber dealers and consumers. The imports from Norway, moreover, consist largely of planed or manufactured wood, which is not yet the case to any considerable extent with those from Sweden, so that, so far as this class of timber is concerned, it is preferable to deal with the two countries separately.

The timber imported from Sweden consists almost exclusively of Scots pine or red fir (*Pinus sylvestris*), and spruce or white fir (*Abies communis*). These are known to traders as Redwood and Whitewood. A small quantity—less than 40,000 loads per annum—of birch and alderwood is likewise obtained in the round state or in the form of bobbins or staves.

The redwoods and whitewoods are received partly in the form of deals, battens, and boards, and partly as square balks, pit-props, and mining-timber; but the wood received in a sawn condition far exceeds the other descriptions both in respect to quantity and value, and constitutes at present the most important supply of building timber consumed in Great Britain. The magnitude of this supply will be best seen from the following figures, giving in loads the quantity of sawn and planed wood exported from Sweden to the United Kingdom during the last six years, as compared with the total import of similar goods from all other countries for a corresponding period :—

	1878.	1879.	1880.	1881	1882.	1883.
From Sweden,	1,150,029	1,173,430	1,264,605	1,091,557	1,339,455	1,366,094
,, all other countries,	2,469,067	2,079,882	2,822,299	2,577,290	2,837,305	2,947,539

Since Sweden furnishes so large a proportion of sawn building timber, it becomes a matter of supreme interest to wood-consumers in Great Britain to inquire whether that country will, in the future, be able to maintain her present position in this respect; and in order to form correct views on this subject, it will be necessary to consider the present condition of the existing forests.

In 1809, prior to the imposition of exorbitant duties on imported European timber, about 120,000 loads of sawn wood were shipped from Sweden, and of this Great Britain received upwards of 80,000 loads. After that year, however, the import duties in Great Britain were doubled (by way of reprisal, on account of the Napoleonic Edicts against British trade), and these again were advanced 25 per cent. in 1813, reaching at the latter date the prohibitive amount of 65s. per load. As a comparatively small duty was, during the same period, levied on timber from British North America, the repressive measures adopted in the former case almost put a stop to the import of timber from the Baltic, so that the tonnage of British vessels arriving in the United Kingdom from that sea, which reached 428,000 tons in 1809, had fallen to 242,000 tons in 1814. After the latter date, and although a reduction in the duty on Baltic timber to 55s. per load took place in 1821 (a duty of 10s. per load being in the meantime levied on wood from Canada), no perceptible increase in the timber import from Sweden was observable until towards the year 1840. This may be seen from the fact that in 1842 the tonnage of British vessels arriving from the Baltic only reached 295,435 tons, or nearly one-third less than in 1809. The duty on European woods was, in 1842, reduced to 30s. per load for sawn, and 24s. for hewn timber, about 1s. per load being then exacted on such imports from the British colonies. In 1851 the former were again lowered to 10s. and 7s. 6d. respectively, and were further reduced to a nominal amount in 1860, prior to their total abolition in 1866.

As a natural result of such repressive measures during the early part of the century, the trade in timber between this country and Sweden was almost strangled, and as no other important outlet for such produce existed, the Swedish forests had practically no money value prior to 1840. It is true, that long before that date a considerable quantity of raw material was required to feed the saw-mills established in the district supplying Gothenburg, but it is equally certain that the value of the sawn product was practically equal to that of the labour expended *plus* the merchant's profit on the same. Such being the case, it is evident that owners of forests of but nominal value were nowise careful as to their management, and it is notorious that even after 1840 large tracts of growing timber were burnt by their proprietors for the purpose of obtaining a crop or two of oats from the ground, the wood ashes being valuable as manure in such cases. This state of things occurred in the south of Stockholm, even as late as 1850. The immense sawmill industry now prosecuted along the coast to the north of that city, and extending to the northern limit of the Gulf of Bothnia, had at that time no existence, nor did the forests there possess any value as realisable property. Such considerations go far to explain the unsatisfactory condition of the Swedish forests at the present day, and render it probable that the assertions of those who predict a period of exhaustion for the same before the close of the present century will be borne out by the result.

As bearing on this question, it may be well here to give the figures of the total Swedish export of sawn and planed wood, not only to Great Britain, but also to all other countries, for the last eighteen years; since about the beginning of that period fears were first expressed that the export was developing too rapidly for the reproductive power of theforests. The figures are as follows :—

Year.	Loads.	Year.	Loads.	Year.	Loads.
1866.	1,124,000	1872.	1,816,000	1878.	1,864,500
1867.	1,274,000	1873.	1,768,000	1879.	2,046,000
1868.	1,424,000	1874.	1,660,000	1880.	2,095,000
1869.	1,438,000	1875.	1,642,000	1881.	2,178,000
1870.	1,548,000	1876.	1,936,000	1882.	2,366,238
1871.	1,616,000	1877.	2,104,000	1883.	2,482,603

That a vast increase in the demand has taken place is at once apparent, and this augmentation has especially occurred in France, Belgium, and Australia. Thus, while Great Britain received 1,150,029 loads in 1878, and 1,366,094 loads in 1883, the exports to other countries advanced from 714,471 loads to 1,165,509 loads during the same period, giving an increase of 216,065 loads in the former case, and 402,038 loads in the latter. It is to be noted that of this immense production not more than 325,000 loads are annually shipped from ports south of Stockholm, and that this quantity has been practically stationary for the last fifteen years. This fact goes far to prove that the forests of the south and centre of Sweden are suffering from exhaustion at the present time, and that for a number of years no increased supply can be expected from that quarter, hence in determining whether Sweden can maintain or increase its present exportation, the district watered by the rivers falling into the Gulf of Bothnia, from the Dal river in the south to the Haparanda at the head of the Gulf in the north, need alone be considered.

Although fears had been from time to time expressed at an earlier period that the woodlands were being too rapidly felled, it was not until about the year 1867 that the Swedish Government began to attach much importance to these outcries. In 1868 a Royal Commission was appointed to report on the available forest resources of the province of Norrland (which supplies nearly all the wood shipped between Gefle and Haparanda), and to determine whether the reports as to over-production had any basis in fact. Late in 1870 this Committee reported, *that, taking the export of the year* 1868 *as a basis, a very considerable over-production was then taking place.* The actual timber-bearing area of Norrland was estimated at 24,057,607 English acres, and calculated to produce annually for export, in the condition of the forests at that time, and keeping within the reproductive power of the same, 75,188,130 cubic feet of logs ten inches and upwards in diameter, and 193,000,814 cubic feet of smaller timber, or a total of 268,188,944 cubic feet of all dimensions.

The Committee further calculated that, as soon as the forests reported on were brought into the fullest reproductive growth of which they were capable, and when proper management was in force, they could supply annually, over and above local wants, 174,414,570 cubic feet of logs ten inches and upwards in diameter, and 283,797,888 cubic feet of timber of smaller dimensions, or 458,212,458 cubic feet altogether.

It will of course be understood that but a very small portion of the timber under ten inches in diameter can be utilised for sawing; and if but one-fifth of the cubic contents of the small timber is suitable for this purpose—which is probably not far from the truth—a total of 113,788,293 cubic feet of logs is annually available for manufacture from Norrland. Adding to this the estimated yearly supply which the forests of the province of Dalecarlia are capable of rendering (these are shipped at Gefle, in the south of Norrland, although grown outside of the latter province), that is, about 14,000,000 cubic feet, a total of 127,788,293 cubic feet of round logs is obtained, which is equivalent to about 81,784,508 cubic feet of deals, battens, and boards, or 1,635,690 loads. According to this calculation, Sweden is cutting at present fully 400,000 loads of sawn wood more than the reproductive power of her forests warrant, although there would seem to have been no overcut in 1868, as reported by the Committee.

Were the forests of Norrland and other districts in the condition in which they ought to be, according to the Report of the Commission referred to above, they might produce, without injury to their reproductive power, not less than 3,500,000 loads of sawn wood per annum for export, in addition to the other timber supplied by that country. This is about a million loads more than has ever yet been sent out of the country, but there is little chance of attaining to such an ideal state; and even if it were possible, a certain proportion of the timber would always remain inaccessible in a rocky country such as that now being considered.

On the other hand, the fifteen years which have elapsed since 1868, have strengthened the conviction that the result to which the Committee arrived as to the *then* available annual quantity of timber, from ten inches and upwards in diameter, was far too low. Had this not been the case, it is quite clear that the value of growing wood in the north of Sweden would either have advanced in price more than it has done since 1868, or, if this did not take place owing to competition from other sources, an increase of a million loads in the export would not have occurred since that date. As it is, however, the augmentation clearly points to the conclusion that timber has been most plentiful and cheap in Sweden, when the quality of the wood, and the relative cost of putting it in a sawn state into the British and Continental markets, are taken into account.

Since 1870 much has been done in the way of putting, not only the forest property of the Swedish Government, but also that of private individuals, into a rational system of circulation. An immense advance has also been made in opening up inaccessible forest tracts, partly by means of railways, and still more by the utilisation of rivers and streams for floating purposes, but much still remains to be done in the latter respect in the drainage basin of the upper reaches of the Gulf of Bothnia, where very extensive tracts of State forests are being slowly made available. It is doubtless the district of Norrland, lying to the north of Hernösand, and especially the Umea and Lulea districts, that will have to supply any large future increase that Sweden may be called on to produce. The large tract of country lying between the Ume and Tornea rivers exports at present but one-fifth of the quantity shipped from the ports between Umea and Gefle, although the area of the former district is greater than that of the latter. It is true that all areas at present but partially accessible may be in time brought within easier reach, yet there is, after all, but too much reason to fear that Sweden will not, in the future, be able to export permanently more than 3,000,000 loads of sawn and planed wood, and that by the time this quantity is reached a period of partial exhaustion will ensue. That this period will arrive before the close of the present century, and make itself felt several years beforehand by a steady rise in the value of forest property, seems certain; and that the price of building timber in Great Britain, such as the best Swedish brands of redwood shipped from the Gefle, Soderhamn, and Sundswall districts, will advance considerably at the time indicated, is unavoidable, unless other and cheaper supplies can be made available. *Compulsory replanting laws should be at once enacted for Sweden.*

The timber imported from Norway, like that from Sweden, consists almost exclusively of Scots pine and spruce, but, in contradistinction to the latter, the wood arrives from Norway largely in a planed or manufactured state. For the purpose of showing the development of this branch of Norwegian trade, partly at the expense of the sawn or deal trade, the following figures, giving the approximate number of loads, of each of these descriptions shipped from Norway to all countries for the last fifteen years, may be of interest:—

Year.	1869.	1870.	1871.	1872.	1873.
Planed wood, . .	132,000	165,000	165,000	198,000	198,000
Sawn ,, . .	759,000	660,000	660,000	693,000	660,000
Year.	1874.	1875.	1876.	1877.	1878.
Planed wood, . .	198,000	198,000	231,000	251,000	254,900
Sawn ,, . .	561,000	396,000	528,000	487,100	344,400
Year.	1879.	1880.	1881.	1882.	1883.
Planed wood, . .	259,100	304,300	358,000	364,900	389,400
Sawn ,, . .	277,900	385,900	359,200	424,400	383,400

This statistical return proves beyond the possibility of doubt that the Norwegian forests are partially denuded of their heavy timber, and that a period of exhaustion set in about fifteen years ago, the total export of sawn and planed wood combined reaching 772,800 loads in 1883, whereas in 1869 the same amounted to no less than 891,000 loads. Nor is this all. Concurrently with the diminution just indicated, at least 60,000 loads included in the Norwegian export for last year were actually goods grown in Sweden, but were despatched by rail or water to Norway for convenience of shipment—a disturbing influence which was almost wholly wanting in 1869.

The Norwegians, being thus unable to obtain heavy timber in sufficient quantity for their saw-mills, were reduced to the necessity of working up their sawn wood into a manufactured state as much as possible, and in this they have been most successful. In spite of the closing of the German market for Norwegian planed timber, so steady has been the progress in the working up of deals into manufactured wood for other countries, that the German prohibition has not been felt. In point of fact, the shipment of *sawn wood* of the better qualities bids fair to cease before long, and to be supplanted by exportation of planed timber, an industry that has developed during the last twenty years.

The quantities[1] of Norwegian sawn and planed wood bought by the United Kingdom for the last six years are as follows:—

Year.	1878.	1879.	1880.	1881.	1882.	1883.
Planed wood, .	165,544	147,405	198,861	204,367	182,595	209,646
Sawn wood, . .	137,905	85,795	144,730	126,542	130,880	142,335
Deal and batten ends,	47,776	38,146	35,810	36,995	40,304	42,919
Staves of all kinds,	36,223	34,067	38,250	44,284	41,976	55,900

Many of the larger saw-mill owners of Norway have been buying up exhausted tracts of forest for the last ten years, both in their own country and Sweden. These tracts have been put under proper management, and will doubtless enable Norway in the future to increase her output in some degree. The figures quoted, however, afford no hope that the United Kingdom will be able to obtain any perceptibly larger quantity of sawn and planed wood, in the aggregate, from Norway, than is at present being received, while it is probable that the continental countries and the Australian colonies will compete to even a greater extent than they are at present doing for the available supply.

With respect to the import of hewn timber from Sweden and Norway, the following are the statistics furnished by the Board of Trade for the last six years :—

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[1] The figures represent loads.

Year.	1878.	1879.	1880.	1881.	1882.	1883.
Loads, .	468,096	436,653	658,881	600,002	609,187	630,041

If there is deducted from the above the quantity of hewn timber officially reported to have been shipped from Norway *alone* to this country during the years above named, viz.—

Year.	1878.	1879.	1880.	1881.	1882.	1883.
Large balks, loads,	78,560	82,450	81,697	44,264	41,445	38,387
Mining timber and props, ,,	285,225	304,409	438,890	421,698	420,777	466,532
Together, .	363,785	386,859	520,587	465,962	462,222	504,919

the remainders will give our Swedish imports of these goods, viz.—

Year.	1878.	1879.	1880.	1881.	1882.	1883.
Loads, .	104,311	49,794	138,294	134,040	146,965	125,122

But those figures represent absurdly small quantities—less even than the amount of mining wood shipped from the port of Gothenburg alone. On an average of years the hewn timber purchased from Sweden will be rather over than under 275,000 loads annually. Hence it is manifest that the Board of Trade statistics of hewn wood imported from Scandinavia are erroneous, and as such mislead the trade.

In the Swedish official export returns, the quantity despatched to this country is not separately stated, but we find that in 1877, 174,166 loads of pit-props *alone* were shipped to British ports in addition to large quantities of mining timber and square balks, reaching considerably over 100,000 loads. There is no reason to believe that the supply of mining wood of all kinds is less now than in 1877, but rather the contrary.

The total cubic contents of large balk timber from Scandinavia is, on the other hand, less now than it was twenty years ago, having been driven out of the market, partly by timber from North Germany and by pitch pine—which can be had of larger sizes—but mostly by the local demand for the Swedish saw-mills. As the Swedish and Norwegian balks consist nearly exclusively of overgrown trees, and the latter are becoming scarcer, it may be confidently anticipated that the 150,000 loads now received will further diminish, and that we must soon look elsewhere for our supply of this description of timber.

With regard to our requirements of pit-props and mining timber, the imported portion of which (with the exception of the props used in the Bristol Channel district, which come from France and Spain) is nearly all received from Norway and Sweden, the quantity available is practically inexhaustible. The only danger that can threaten this branch of the trade is, that the Swedish Riksdag may prohibit the export of this small wood from the south of Sweden, as they have done from the extreme north of the country. Of this, however, there is little likelihood, for the next decade at least, although such a measure would be popular with the owners of saw-mills and ironworks in that country.

RUSSIA.

Our supplies of timber received direct from Russian ports consist mostly of soft-woods, which belong to the same family as those from Scandinavia, and which are obtained from three distinct sources, viz., from Finland, the so-called Baltic Provinces, and from the district adjoining the White Sea.

The forests of Finland consist almost exclusively of Scots pine, spruce, alder, birch, and aspen. Of these only the two first are exported to any appreciable extent, and the following figures indicate in loads the total shipment from Finland to all countries for the last eight years:—

Year.	1876.	1877.	1878.	1879.
Sawn timber, . . .	780,273	936,284	651,810	628,792
Unmanufactured timber, .	198,327	181,516	144,590	61,167
Year.	**1880.**	**1881.**	**1882.**	**1883.**
Sawn timber, . . .	1,014,214	783,987	962,127	883,857
Unmanufactured timber, .	104,421	215,623	116,942	209,011

The following table, which shows in greater detail the export of deals, boards and battens from Finland during the eight years from 1876-1883, is also of great interest :—

	1876.	1877.	1878.	1879.	1880.	1881.	1882.	1883.
From	Cubic feet.	Cubic feet.	Cubic feet.	Cubic feet.	Cubic feet.	Cubic feet.	Cubic feet.	Cubic feet.
Tornea, ...	128,770	861,724	655,615	540,774	917,316	759,259	659,321	630,966
Kemi, ...	1,348,231	2,496,740	793,355	471,622	724,493	472,075	829,660	958,863
Uleaborg, ...	1,838,851	2,173,619	1,376,636	1,925,101	3,224,510	3,068,114	4,008,032	3,576,247
Brahestad, ...	21,620	162,727	115,614	151,812	210,612	102,195	283,422	222.051
Gamla Carleby, . .	146,150	173,627	96,091	65,448	55,104	4,032	76,588	120,980
Jacobstad, ...	442,854	613,194	400,162	202,516	934,136	355,259	715,411	128,671
Ny Carleby, . . .	307,855	319,069	342,677	71,937	692,499	289,492	390,038	192,535
Wasa, ...	94,446	89,969	74,374	40,170	102,547	72,349	116,077	155,667
Kaskö, ...	1,728	...	...	180	62,224	9,500	101,645	16,355
Christinestad, . .	948,456	794,178	588,821	757,255	1,007,153	1,067,376	691,700	823,698
Björneborg, . . .	7,570,131	8,485,781	6,310,495	6,938,323	9,440,915	7,630,993	8,797,962	7,371,149
Raumo, ...	822,203	672,015	466,049	372,695	893,510	1,173,625	1,335,362	1,275,181
Nystad, ...	428,177	225,284	384.498	186,853	290,350	326,978	415,059	323,764
Abo, ...	1,522.021	2,618,060	2,429,735	1,702,893	3,610,444	3,564,717	4,727,979	4,736,673
Hangö, ...	285,222	339,409	199,184	259,165	900,053	2,439,897	572,144	305,067
Helsingfors, . . .	3,176,542	4.124,199	2,134,394	551,939	2,683,024	2,713,886	3,662,496	2,425,964
Borga, ...	739,985	858,166	730,395	675,357	1,510,427	1,451,934	1,670,551	2,044,344
Lovisa, ...	1,481,045	1,220,108	877,080	241,290	1,837,397	1,096,719	1,273,600	1,508,813
Kotka, ...	...	8,956,809	6,172,427	6,873,972	9,737,052	7,677,639	8,027,911	8,796,262
Fredrikshamn, . .	7,106,303	370,295	7,455	78,494	403,482	214,112	236,966	436,645
Wyborg, ...	9,512,193	10,299,075	7,631,352	8,204,822	10,724,605	6,215,790	8,657,973	6,804,479
Sundries, ...	1,090,880	1,010,148	803,593	1,126,987	748,867	493,434	856,467	1,338,448
Cubic feet, .	39,013,663	46,814,186	32,590,524	31,439,605	50,710,720	39,199,375	48,106,364	44,192,831
St. Pet. Stds, . .	236,446	283,722	197,518	190,543	307,338	237,572	291,553	267,835

Of the above 883,857 loads of sawn timber exported during 1883, 383,272 loads consisted of deals, battens, and boards despatched to Great Britain. Very little hewn timber is thus imported into this country from Finland, the bulk of this description of wood being sent to Holland and other parts of the Continent. Part of the round timber, however, is shipped to England for mining purposes, and a large quantity of fir staves for cement casks and use in chemical works is likewise obtained from the same source.

With regard to the question as to whether any considerable increase in the supply of wood can be anticipated from Finland, it is well to bear in mind that nearly six-sevenths of the timber exported from that country is shipped from ports lying south of the 62d parallel of latitude, or between Wyborg or Björneborg, and only about one-seventh from places situated to the north of the latter port, although large forests of Scots pine and spruce are to be found up to the polar circle. Again, one half of this six-sevenths is shipped exclusively from the two ports of Kotka and Wyborg, lying near each other at the east end of the Gulf of Finland, and both of these ports have a sufficient extent of forest at their back nearly to double their present output of sawn wood. The timber trade of Kotka is, in fact, almost entirely a creation of the last fifteen years. The only other port whence any large amount of timber is shipped is Björneborg. Although the heavy timber near the coast has mostly been cut from the tract of country lying between Kotka and Björneborg, there is little doubt that, by a liberal expenditure of money in clearing away obstructions to floating in the waterways leading from the coast to the lakes in the interior, a very large development of the output is practicable in the district indicated.

It is, however, to the north of Björneborg that we look to the greatest possibilities of future increase in the supply. The immense forests of the north of Finland are evidently capable of a far greater output than 150,000 loads per annum, and it cannot be doubted that half a million loads of sawn wood might be annually taken from these forests without injuring their reproductive capacity. To enable this to be effected, the Finnish Government, as owner of more than half the northern forests, will have to offer inducements to capitalists willing to expend money in opening up the rivers for floating purposes.

The most feasible way to do this will be either to grant long cutting leases of suitable forest limits at a low rental, or to charge a nominal royalty for a given number of large trees, as is done by the Swedish Government.

The Finnish timber, as a rule, is somewhat inferior in quality and more knotty than the Swedish wood from the Lower Gulf ports, and it is not by any means handled with the same care after sawing. The system of short leases of forest tracts, which mostly obtains in the south of Finland, greatly checks the work of placing the Finnish wood trade on a substantial basis. This objection ought not, however, to apply to the north of Finland, where the State is the principal forest proprietor; and it is extremely probable that, as soon as the demand has used up all the supply that the Swedish forests can furnish, or as soon as the latter are showing signs of temporary exhaustion, a large increase in the import of building timber from the "Land of the Thousand Lakes" may be looked for.

The reasons already given to explain the present bad condition of the Swedish forests apply with still greater force to the forests of Finland. Here the timber industry was of little account a quarter of a century ago, and, as the growing trees had no value, their owners treated them almost as enemies. The supervision not only of the private forests, but also of those belonging to the State, still leaves much to be desired, while the replanting of cut areas ought to be made compulsory, not only in Finland, but also in other portions of the Russian dominions. The Finnish export duty on wood is likewise an undesirable method of raising revenue in a State which owns itself about half the forests of the country, and ought to be abolished.

In the Baltic provinces of Russia, including the whole seaboard from St. Petersburg to the German frontier, the principal ports from which we receive wood goods are those of St. Petersburg, Riga, and Libau. From St. Petersburg we obtain a very good quality of redwood or Scots pine deal, but the best of this timber has apparently been taken out of the most accessible forests, as the quality now obtained is inferior to that received twelve years ago. The quantity of spruce or whitewood exported is, however, still greater than that of redwood, although the shipment of the latter is increasing with greater rapidity than that of the former. The export statistics for the last nine years read as follows :—

For 1875, 214,341 loads.
,, 1876, 240,203 ,,
,, 1877, 255,859 ,,
,, 1878, 236,033 ,,
,, 1879, 189,720 ,,
For 1880, 221,489 loads.
,, 1881, 234,805 ,,
,, 1882, 316,100 ,,
,, 1883, 297,320 ,,

Of the above, the amounts despatched to Great Britain were—

In 1880, 175,339 loads.
,, 1881, 187,622 ,,
In 1882, 246,130 loads.
,, 1883, 239,573 ,,

The greater part of the balance usually goes to Holland. A considerable quantity of poles and lathwood is likewise received by Britain every year from St. Petersburg.

The Riga exports comprise principally spruce deals and railway sleepers, or sleeper blocks, and for these articles the Riga district is the largest emporium in Europe. Oak wainscot logs and staves also form standing items sent from this port. The available statistics of the quantities of wood bought by Great Britain are very meagre, but, according to a calculation made for 1883, about 262,501 loads of sawn or split timber, and about 180,000 loads of hewn wood, were shipped to this country during that year. The value of the whole timber exports of Riga to countries abroad was 12,911,072 roubles[1] in 1882, against 12,549,694 roubles in 1881. The cubic contents of the wood despatched over sea in 1882 were estimated at 670,000 loads, or fully 200,000 St. Petersburg standard hundreds. Riga enjoys at present the pre-eminence of being the largest timber-exporting port in Europe.

A considerable trade in wood is likewise done by the ports of Libau and Windau, in the same neighbourhood as Riga, and the class of goods exported from these harbours is in all essential respects similar to that sent from Riga.

With reference to the prospect of obtaining future increased supplies from the Baltic provinces of Russia, it may be noted that the import of spruce deals, from the district of which

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[1] 1 silver rouble=3s. 2d. nominal value.

St. Petersburg is the outlet, has not by any means reached the magnitude of which the forests are capable. At the same time, the competition with the cheap spruce, or whitewood, from the Riga district, and from the Hernösand district in Sweden, is so keen, and the demand for timber at the Russian metropolis itself so great, that there is but little chance of a large increase in the supplies of whitewood from the Russian side of the Gulf of Finland. Were prices to rise permanently 20s. per St. Petersburg standard, so as to allow the use of the railway for distances of 300 English miles, matters would be altered considerably.

Further, with respect to the Riga district, the quantity of timber leaving it annually is at present so vast, that it may well be doubted whether the forests supplying the same are able permanently to withstand the drain. If, however, a comparison be made with a representative Swedish district producing a somewhat similar quantity of wood, viz., the Hernösand district, such fears will be much diminished. The Hernösand district, culling its supply from about 3,100,000 English acres of wood-bearing land, produces probably three-fifths of the output of Riga, hence the latter district, comprising, at a low computation, 6,000,000 acres of similar ground, drained by the Dwina river and its tributaries, ought to be able to produce twice as much as Hernösand, without feeling the drain so heavily as the Swedish district. Moreover, the important fact that the period necessary for the reproduction of sawable timber in the Swedish district is at least twenty years longer than that required along the Dwina, cannot be lost sight of in this connection. While Riga can, doubtless, keep up its present supply, it is doubtful whether this can be substantially augmented without an increase of price sufficient to place some of the forests that can at present only be reached by a long railway carriage within the limits of remunerative enterprise.

A considerable trade is done in Riga by exporting small blocks of oak for parquet floors. There exists a large demand for these on the Continent, but none of importance in England, where the art of making beautiful floors, as now practised in Russia, has not yet been appreciated.

Towards the south of Russia a very large quantity of timber is either floated or lightered down the river Dnieper and its tributaries (but especially the Berezina, which falls into the Dnieper a little to the north-west of Gomel) to Cherson, on the Black Sea, where it is either sawn up or distributed in the form of square timber. The kinds of wood thus dealt with comprise a fast-growing resinous red pine, beech, elm, birch, alder, and oak. Very little, however, of these products finds its way to England, except oak wainscot logs and staves from Odessa. Large quantities of very good ash can also be had in this part of Russia, and small parcels have been sent to England from time to time for the use of coachbuilders and cabinetmakers, who highly approve of the wood. Prices are, however, too low at present to induce a large import trade, and the difficulty in floating militates against the economical transport of the logs to the seaboard of Russia.

The imports from the White Sea consist exclusively of the same descriptions of wood as are sent from St. Petersburg, viz., Scots pine and spruce. The redwood or Scots pine from this region ranks as the best in Europe. The places of shipment are Archangel, Onega, Soroka, and Mesane. The statistics of the shipment of sawn wood from Archangel are given as follows :—

Year.	Loads.	Year.	Loads.
1875	95,040	1880	138,683
1876	107,250	1881	97,313
1877	104,610	1882	101,138
1878	87,780	1883	103,105
1879	126,476		

Of this, Great Britain took, in

Year.	Loads.	Year.	Loads.
1875	82,170	1880	119,000 approx.
1876	94,710	1881	84,000 approx.
1877	97,350	1882	89,681
1878	74,910	1883	88,806
1879	112,000 approx.		

The mills of Mesane, Onega, and Soroka produce annually about 50,000 loads of sawn wood for export, the great bulk of which is purchased by this country.

When it is taken into consideration that the forests in the Governments of Archangel and Vologda have an estimated superficial area of 197,100,000 English acres, or at least three times the forest area of Sweden and Norway combined, and further, when it is remembered that much of this area is covered by Scots pine of the best quality in Europe, the fears of timber-consumers in France and England, that famine prices for building timber are possible within the lifetime of the present generation, seem to have no basis in fact.

That the total annual export of timber from this immense district is only about 150,000 loads arises from several causes, the principal of which are (1) the stringent conditions of purchase from the State forests; (2) the obstructed water communication between many of the woods and the coast; and (3), above all, the disgraceful state of the shipping ports, together with the consequent high freights and insurance—the harbours having been allowed to silt up to such a degree that scarcely fourteen feet of water exists, in some cases, inside the bars.

That the Russian Government should devote much time, energy, and capital, to the development of its 103,000,000 dessjatins—equal to about 250,000,000 acres—of forest property is much to be desired, both from the fact that it would further the interests of this country as well as, more particularly, those of its own subjects in Europe; and with the facilities which steam communication affords for removing large quantities of wood from distant points with celerity, it is more than probable that British capital would soon be largely used for the exploitation of the forests of the White Sea basin.

If these forests were properly developed there would certainly be no need for this generation to think of the utilisation of those of Western Siberia, which, according to Professor Nordenskiöld, are the most extensive in the world. The basin of the river Yenesei alone is covered, south of the 68th degree of latitude, with red pine, larch, spruce, silver birch, alder, and the valuable Siberian cedar, in sufficient quantities to supply Western Europe for more than a generation; but before this timber is required it is to be hoped that a better route will have been found to the mouth of this river than would appear to be known at present.

BRITISH NORTH AMERICA.

The timber trade of British North America is principally concentrated within the provinces of New Brunswick and Nova Scotia, and throughout the St. Lawrence and Ottawa river basins. As has already been pointed out, when reviewing the causes which retarded the development of timber import from Sweden, up to about the year 1842—and partially afterwards—a very much lower duty was levied in this country on wood which was the produce of Canada than on similar imports from European nations. This led to the fostering of a very large trade, especially in hewn timber, from Quebec and the lower ports on the St. Lawrence—a region which, forty or fifty years ago, was looked upon as the principal source of our supply. After the duties were more equalised, previous to their total abolition, and in proportion as the Northern States of the American Union increased in population and began to compete with the Quebec merchants for the supply, the dominant position that these merchants had held for many years was gradually lost. Large quantities, however, of yellow pine (or, as it is called in America, white pine) and spruce from the Quebec region, as well as a small supply of red pine, are still obtained; the first being partly hewn and partly sawn, while the second is mostly received in a sawn condition. A considerable quantity of oak, elm, ash, and birch is likewise imported from the district although part of the hardwoods received is *grown* in the United States.

The following return of shipments will best show the movement of the Quebec export trade for the nine years ending with 1882:—

In 1874, 854	timber-carrying	vessels of	636,672	tons cleared out.
,, 1875, 642	do.	do.	478,441	do.
,, 1876, 786	do.	do.	624,110	do.
,, 1877, 796	do.	do.	670,620	do.
,, 1878, 476	do.	do.	399,833	do.
,, 1879, 433	do.	do.	364,628	do.
,, 1880, 634	do.	do.	555,451	do.
,, 1881, 459	do.	do.	380,186	do.
,, 1882, 426	do.	do.	359,925	do.

Small parcels of sawn wood are shipped by steamer from Quebec, and these are not included in the above table; but such supplies, although considerably larger now than they were ten years ago, are not sufficient to alter the fact that this export trade of Quebec is declining. The following is a detailed statement, in loads, of the principal items of which that export was composed, for the last five seasons, viz.:—

	1879.	1880.	1881.	1882.	1883.
Hewn Wood.					
Square and Waney Pine,	106,009	231,051	182,038	158,243	208,540
Red Pine, . . .	16,276	28,664	18,440	20,494	20,979
Oak, ...	33,620	46,337	37,667	39,147	42,658
Elm, ...	10,880	20,836	15,943	15,567	14,798
Birch, ...	3,929	11,177	5,878	42,274	4,661
Sawn Wood.					
Pine deals, . . .	122,602	266,900	177,659	144,315	183,016
Spruce do., . . .	130,740	147,673	141,962	127,752	125,108

The supply of red pine especially has decreased during the last twenty years, about five times the present amount being exported at that period. Pitch pine has, in many instances, taken its place in Europe.

There are no means of ascertaining the exact amount of the Quebec shipments to the United Kingdom, but it is probably about five-sixths of the whole quantity despatched over sea. The total export of Quebec wood to Europe in 1883 had an approximate value of 7,802,550 dollars (£1,560,510). A small but increasing business is likewise now being done with South America.

Further up the river St. Lawrence, the district of Montreal has developed a considerable trade in timber, but as a large part of this goes to the United States, it need only be noted here that the exports to this country are usually about 75,000 loads annually, of which nearly half consists of sawn wood. During the past year, however, 85,325 loads of hewn and sawn timber were forwarded, the bulk of the remaining oversea exports going to the river Plate in South America.

The city of Ottawa, on the Ottawa river, the capital of the

Canadian Dominion, is the headquarters of the timber-manufacturing interest of Canada. The wood goods sawn here are principally pine boards for the United States markets, and it is no exaggeration to say that the Ottawa Valley production of sawn timber is at present the largest in the world. This reached a total of about 1,320,000 loads in 1882, and it would probably be little less last season. Such a production far exceeds that of any district in Europe.

This immense export from Canada to the United States must impress our own importers and consumers with the magnitude of the requirements of the latter country, and the influence that this extensive demand is likely to have on the price of Canadian supplies in the near future cannot be lost sight of.

The Ottawa mills, unlike those in Europe, are mostly driven by water, and usually run day and night, from the middle of May to the beginning of November.

New Brunswick and Nova Scotia, however, must for the present be regarded as the seats *par excellence* of our supply of American spruce. The chief ports that are engaged in shipping this class of goods, are St. John, Miramichi, Dalhousie, Richibucto, and Bathurst, the bulk being despatched from the two first named.

The shipments from Miramichi (including Chatham and Newcastle) in sawn deals were :—

Year	Loads	Year	Loads
In 1877,	250,000 loads.	In 1881,	213,334 loads.
,, 1878,	176,667 ,,	,, 1882,	192,667 ,,
,, 1879,	190,000 ,,	,, 1883,	248,324 ,,
,, 1880,	258,334 ,,		

Of these deal exports, which are almost exclusively spruce, about 80 per cent are bought by the United Kingdom. Small quantities of pine timber are likewise obtained from the Miramichi river. About 100,000 loads of sawn and other timber are also despatched from New Brunswick to the States annually.

The exports of sawn wood from the other principal places in New Brunswick for the last three seasons have been as follows :—

	1881.	1882.	1883.
	Loads.	Loads, approx.	Loads.
From St. John, . . .	339,524	310,000	302,530
,, Dalhousie, . . .	26,397	25,921	31,211
,, Bathurst, . .	26,934	29,021	39,026
,, Richibucto, . . .	25,902	...	35,151

Of the above, which consisted almost wholly of spruce, about 85 per cent were invoiced to the United Kingdom. Small parcels of hewn pine timber are likewise sent to this country from these ports.

In addition to the above ports a number of small places which trade almost exclusively with this kingdom have also developed a fairly extensive timber industry. These are Bay Verte, Shediac, Caraquet, and Sackville, in New Brunswick; and Halifax (which ships a large quantity of deals, staves, and some hard woods, by steamer to Liverpool and other ports), Yarmouth, and Pugwash in Nova Scotia. From three rivers situated between Quebec and Montreal a considerable quantity of deals are shipped, as well as from other places in the Lower Gulf of St. Lawrence.

As the import of hewn wood from British North America to this country is about one-sixth of the whole quantity received, and of sawn wood no less than one-fourth, the problem of future supply from that colony becomes one of the highest importance to wood consumers in Britain.

In connection with this question it is necessary to consider whether the Canadian Dominion can keep up or increase her present output, without endangering the future of her forests, and what proportion of that output will be required at home and in the United States.

In seeking an answer to these queries, only yellow pine, red pine, and spruce need be considered, seeing that the quantities of oak, elm, birch, and ash now being exported are comparatively small.

So far as red pine timber is concerned, the supply has gradually diminished to a quarter of what it was in 1863. The quantity measured in at Quebec in 1882 amounted to

1,474,871 cubic feet, against an average varying from 4,000,000 to 5,000,000 cubic feet twenty years ago. It may therefore be concluded that the quantity obtainable has diminished, and that, with the local demand in Canada itself, and the requirements of the United States, the markets of this country are not likely to receive more of this wood in future. Fortunately a substitute for it has been found in pitch pine, so that it is not much missed.

Hewn and sawn yellow pine is a most valuable description of timber, and when of the finest grades is unrivalled for many purposes, such as house-building and other wood-work. It has been largely and continuously imported into this country for more than fifty years, and a fully equivalent substitute will be difficult to find. The White Sea redwood approaches nearest to it in point of quality, but the latter, in addition to its smaller dimensions and greater knottiness, has other defects that diminish its value in comparison with the former. The quantity of hewn yellow pine received at the principal port from which we obtain our supplies (viz. Quebec) was, in 1876, about 19,243,733 cubic feet, whereas in 1883 it was but 11,198,557 cubic feet, or taking the average for the years 1871 to 1875 inclusive, it exceeded 14,000,000 cubic feet per annum; while for the last five seasons, 1879 to 1883 inclusive, it was but 8,412,654 cubic feet. On the other hand, the supply of yellow pine deals to Quebec has not decreased in so pronounced a manner, for although in 1876 it reached 278,363 loads, and only 147,979 loads in 1883, the average of the last five years was 187,187 loads, against 238,731 loads on an average for the five years ending with 1880. Such figures, in conjunction with the history of the quantity exported of late years, bear abundant evidence to the fact that a diminished quantity is available for export to Europe.

The great bulk of the yellow pine now remaining in Canada is growing on that vast territory of over 100,000 square miles in area, which is watered by the Ottawa, St. Maurice, and Saguenay rivers and their tributaries. Of these by far the most important is the Ottawa Valley supply, of the production from which, amounting to about 400,000 St. Petersburg standard hundreds of all descriptions of sawn wood, only a tithe reaches this country, the remainder being consumed in the United States. That a considerable quantity of yellow pine exists in the Muskoka and Nipissing regions, and in the Georgian Bay country, is beyond doubt, but these supplies, as well as those from some newly-discovered pine tracts near Lake Superior, have either been already very much drawn upon for local and United States demands, or will be so to such an extent in the near future, that little hope exists of British consumers being in a position to pay such prices as will insure the purchase of any of these goods. The eastern townships of the province of Quebec, perhaps as far as Mingan, are also said still to contain a considerable quantity of yellow pine, but not of first quality. These districts are also comparatively small and scattered, and, with the exception of the Bersimis, have been worked over for a long series of years, so that the best trees have been cut as far as they have been accessible.

In discussing the duration of the yellow pine forests of Canada, in relation to the timber supply of this country, it may here be remarked that the question is fast becoming one of but secondary importance to our timber consumers, as far as the lower qualities of the wood are concerned. In spite of the fact that prices have been gradually rising in Canada for the growing wood, and that a diminished supply has at the same time been brought to this country, the prices obtainable here at present, and for some years past, have left no commensurate profit to the exporters. The conclusion, therefore, to which a diminution in exportation points is: *that, except for a small quantity of prime yellow pine, a substitute for which cannot be found in Europe, Britain is economically unable to pay a price equivalent to what the United States can do, and must consequently be content to see the latter country intercepting an ever-increasing proportion of this fine wood.*

To make this clear, reference may be made to the attempt which was made in connection with the last Census of the American Republic to ascertain the quantity of mature yellow pine then existent in that country and ready for the axe. Professor Sargent, who had charge of this part of the Census, reported in 1882 in these words:—“The entire supply (of white pine) growing in the United States, and ready for the axe, does not to-day greatly, if at all, exceed 80,000,000,000 feet; and this estimate includes the small and inferior trees which, a few years ago, would not have been considered worth counting. The annual production of this timber is not far from 10,000,000,000 feet, and the demand is constantly and rapidly increasing."

According to this semi-official statement, there was, two years ago, only about eight years' supply, and now there is supposed to be only six or seven years' consumption! There is, fortunately, reason to believe that the statement is inaccurate, and proof of the assertion that the United States consume 5,050,000 St. Petersburg standard hundreds, or 16,665,000 loads of yellow (or white) pine wood annually, will be awaited with interest. The Professor has not, apparently, taken into consideration the circumstance that Canada supplies a good percentage of the present United States consumption; neither has he defined the precise minimum dimension which the Census assessors have put down as ready for the axe. The large number of trees, too, which, in the course of eight or ten years will reach the cutting size, although now a trifle under it, must also be considered. Taking credit for all these items, however, and assuming the available quantity to be as much underrated as the consumption is evidently over-estimated, the outlook is sufficiently alarming, and amply justifies compulsory replanting enactments wherever the ground is best adapted for the production of forest.

The fertility of much of the old forest ground both in Canada and the United States renders the enacting of such compulsory replanting Acts far more difficult than similar legislation in Scandinavia and Russia—where much of the ground is absolutely worthless for agriculture—were even the freer political instincts in the former countries not to place at present insurmountable obstacles to such an interference with the so-called rights of property. When, however, it is borne in mind that it takes at least ninety years to produce a yellow pine saw-log, the United States will assuredly in a short time require not only all its own yellow pine, but also most of what its Canadian neighbours can spare for its use.

As regards American spruce, which competes with Swedish and Russian whitewood—and which, on the west coast and in Ireland, exceeds the latter in price,—it is to be remarked that the import of this description of sawn wood to the United Kingdom probably amounts to an average of six or seven hundred thousand loads annually. As any threatened stoppage of this import would at once send up the price of competing European whitewood considerably, the question of its future supply becomes in consequence one of paramount weight. One of the most important facts to be borne in mind in reflecting on this question, is the ease, rapidity, and spontaneous manner in which this tree reproduces itself. Unlike yellow pine, which requires a century to grow a standard log, spruce is almost irrepressible, and a spruce forest from which all the trees measuring twelve inches and upwards in diameter have been taken, will, after a rest of two decades, be ready to work again. On the other hand, Swedish whitewood from the Sundswall district requires forty years longer than the average Canadian spruce to come to maturity. Hence this is one important reason why the raising of the latter costs so much less than European, and especially Swedish whitewood.

As far as we are aware, no systematic attempt has been made by the Canadian authorities to reduce to figures the available quantity of mature spruce now growing in New Brunswick, Nova Scotia, and the immense forest belt before referred to which lies between the Ottawa river basin in the west and Mingan in the east. All these districts, however, according to Mr. Joly, late Premier of the Province of Quebec, contain immense quantities of spruce, and it seems likely that there will be sufficient for many years' home consumption, unless it be swallowed up by the United States, after the people of that territory have used up all their own yellow pine and spruce.

Without being in a position to contest the assertion that the United States' and local Canadian requirements may intercept most of the spruce coming into the market to the *west* of Montreal, no satisfactory evidence has yet been adduced to prove that the large quantity available to the *east* of that point—including the districts north and south of the St. Lawrence, as well as New Brunswick and Nova Scotia—will not, as heretofore, find its best market in Great Britain. There is, it is true, a considerable demand across the border for New Brunswick spruce, but this demand is not much, if at all, over 100,000 loads annually, and is not likely to increase largely before the American import duty on wood goods is abolished. Even were this contingency to take place, the quantity of woodland possessed by the States of Maine and New York makes any abnormal increase in the import of spruce from the Dominion improbable in the case of these, the only States capable at present of consuming large supplies of New Brunswick wood. It is not generally known that the State of New York itself contains a woodland area equal to 22 per cent. of its total superficies. The Adirondacks region, for instance, contains nearly 2500 square miles of unbroken forest, filled with a second growth of spruce, yellow pine, and hardwoods, probably much superior to the first, as "virgin forests" usually contain a mass of overgrown timber full of black knots. Again, in the New England States, many disused and partially exhausted tracts of agricultural land are being covered with a new growth of pine, which in many places is approaching a usable size. The value of the logs cut in Massachusetts in 1880 was nearly £400,000, and of these at least one-half are said to have been of the second-growth yellow pine. In the States of New Hampshire, Vermont, and Maine, about 320,000 loads of sawn yellow pine were likewise produced in 1880, and mostly from this second growth. These figures are of themselves sufficient to relieve us from the apprehension of undue competition on the part of the Eastern States of the Union for the spruce of New Brunswick, Nova Scotia, and the eastern townships of the province of Quebec, for many years to come. Moreover, with the great possibilities of cheap water-carriage which the development of steam shipping puts into our hands, the probability of the enormous tract of country on the east side of Hudson's Bay, and the south of James's Bay, being made accessible for the supply of spruce, silver fir, and the several descriptions of pine, with which the country has been proved to abound, must ever be kept in view. The distance from James' Bay to Liverpool is about equal to that from Quebec.

The immense area of nearly primeval forest possessed by British Columbia must also be referred to, because, although not yet directly of importance to the timber consumers of this country, it will in the future doubtless relieve the north of Europe from what would otherwise become a very heavy demand from our fellow-subjects beneath the Southern Cross. That the requirements of Australia have already reached large proportions will be apparent from the fact that, with the exception of Great Britain, no country is at present buying more Norwegian planed wood than the colonies of that continent. The most important tree in British Columbia is the Douglas fir (*Pseudo-Tsuga Douglasii*).

THE UNITED STATES.

As might be anticipated, the Northern States of the Union, that are increasing with such rapidity in population, require all their building timber for home use; and our import therefore from the principal North Atlantic ports is mostly restricted to hard-woods or specialities in soft-woods, with the exception of small parcels of yellow pine from Maine. Large quantities of staves are obtained from Philadelphia, Boston, New York, and other ports, as well as wood-ware from the two latter places, and considerable quantities of joiners' goods are bought at New York, or the district of which it is the outlet, in addition to oak, elm, maple, and ash, either hewn or in a more or less manufactured state. Walnut, which has been so largely used of late years for house furniture, is mostly obtained from the Atlantic ports of the States, and it is reported that old walnut-tree stumps, which the earliest settlers on some of the farms had been unable to burn when they were clearing the land, have been lately sold for more than the entire property for which they had originally been sacrificed is now worth; and that the old black walnut fence-rails, with which the property had been originally enclosed, have been taken up and sold for sums which the early settlers who split them would have looked upon as a fortune.

The Americans of these Northern States are very skilful wood-workers, and whether it is a question of supplying wainscot logs, house-furnishings, packing-case boards three-sixteenths of an inch thick, or broom-handles, they are equally at home; in fact, whenever there is a demand for any unusual dimension or pattern of anything, their quick mechanical genius grasps the gist of the requirement so rapidly that they have the article ready for delivery before their slower rivals in the north of Europe have adapted their machinery for the job. Figures have not been collected to show the contents or value of manufactured woods imported from the States, but it is well known that these are rapidly increasing. In order to give an idea of the vast extent of the United States timber trade, it may be noted that Chicago alone, which is the great distributing centre, handles fully 1,000,000 St. Petersburg standard hundreds, or 3,300,000 loads of soft-woods annually.

The great bulk of the timber we purchase from the United States is, however, shipped from the so-called Pitch Pine States, situated to the east of the Mississippi river, namely, the Carolinas, Georgia, Florida, Alabama, and Mississippi; and consists mostly of pitch pine timber (the *Pinus Australis* of Michaux, otherwise the "Southern Pine"). The principal ports which export this class of wood are Pensacola, Doboy, Apalachicola, Pascagoula, Mobile, Darien, Brunswick, and Savannah; but about one-half comes from Pensacola. The consignments from that port to Great Britain for the last three seasons were as follows:—

Year.	1881.	1882.	1883.
Hewn timber, . .	68,694 loads.	57,701 loads.	27,103 loads.
Sawn ,, . .	132,244 ,,	131,123 ,,	142,225 ,,

A considerable amount of timber is likewise despatched from Pensacola to Antwerp, and other leading continental ports.

The imports of hewn and sawn timber from Mobile amounted to 9246 and 28,940 loads during the years 1880 and 1881 respectively.

From the Georgian ports there were despatched to Europe and South America in 1881 the subjoined quantities of hewn and sawn wood:—

From Savannah, ...	about 40,000 loads
,, Darien, ...	,, 56,000 ,,
,, Brunswick, ...	,, 43,000 ,,
,, St. Mary, ...	,, 8,300 ,,
Or a total of .	147,300 ,,

Of this possibly one-half was bought by this country. Nearly 300,000 loads were shipped to the Northern States during the year named from the four ports above referred to.

Although no figures exist to show the extent of the European timber business carried on by Doboy, Apalachicola, and Pascagoula, it is well known that their exports are rapidly augmenting. From New Orleans a large quantity of pipe and other staves, and from Norfolk (Virginia) treenails, and other goods, are received.

The northern limit of the pitch pine (which is known in the Northern and Middle States as "Yellow Pine," "Southern Pine," or "Red Pine,") is the river Muse in North Carolina. It appears at first in association with the so-called yellow pine (*Pinus mitis*), the pond pine (*Pinus serotina*), as well as the black oak (*Quercus nigra*), and scrub oak (*Quercus Bannisteri*). It soon, however, parts company with these, and at the 35th degree of north latitude it is found almost in unbroken forests, varied by an occasional patch of scrub oak where the soil is very dry and sandy.

The wood of the pitch pine tree is the heaviest of the pine family, and, like all highly resinous woods, is supposed to possess great durability in climates of moderate severity. A very large industry has been developed in the Southern States in connection with the gathering of its resinous products, such as tar, turpentine, pitch and the like. Turpentine is the raw sap of the tree, and the "boxing" or tapping necessary to collect this is no doubt injurious to the "alburnum" or sapwood, although it has probably little effect on the heartwood or "duramen."

The pitch pine trade to this country has been entirely developed during the last twenty years, but seeing that its importation is extending so rapidly, and displacing the pine of Canada, which is at present showing signs of exhaustion, the available supply becomes a question of great moment. This, however, according to all the writers of the Northern States, is extensive, and the Southern States, by a general consensus of opinion, are pointed to as the future seat of the timber trade. The State of Georgia, for example, contains an area of about 35,515,000 acres, and of these about 11,500,000 are covered by the so-called "Pine Belt." Allowing for cultivated land, 6,000,000 acres of wood-bearing forest, may, at a low computation, be calculated on with certainty. According to the British Consul at Savannah, two years ago there existed "a vast territory tributary to Savannah, of lands untouched by the woodman's axe, either for timber purposes or turpentine."

In North Carolina there are said to be about 30,000 square miles of nearly unbroken forest, containing pine, oak, maple, beech, and hickory. Of this immense area by far the larger portion is monopolised by the "Southern pine;" and one may still ride through miles of forest without seeing a house or other signs of civilised life. It is only in the vicinity of the streams, or near a railway, that they have been much interfered with by the lumberman or the collector of turpentine.

The United States Census Report of 1880 gives the following estimate of the available quantity of merchantable pine standing on the 31st of May of that year, together with the amount cut in 1879, in the States of Florida, Alabama, Mississippi, and Texas.

Alabama	contained	31,475,000	loads, while	408,993	loads were	cut in 1879.
Florida	,,	11,025,000	,,	346,758	,,	,,
Mississippi	,,	39,958,334	,,	192,958	,,	,,
Texas	,,	112,514,166	,,	457,400	,,	,,

Assuming this Report to be correct, and that the rate of cutting would continue equal to that of 1879, there existed in 1880 a supply for upwards of 77 years in Alabama, for 32 years in Florida, for 207 years in Mississippi, and for no less than 246 years in Texas. In other words, in the two latter States, according to the evidence of the Federal Government itself, there are millions of trees which are now rotting because they are not cut down and placed in the market.

Again, the State of Louisiana bears an estimated quantity of 133,000,000 loads of mature pine timber, oak of several varieties, cotton-wood tree, gum tree, and black walnut, and of this at least 50,000,000 loads are pine. Large quantities of so-called live oak are growing in the swamps of that State. This tree is almost impervious to water, and is therefore especially valuable for shipbuilding and cognate purposes. The white oak of the same State has few, if any, rivals for tough barrels, and it is from this wood that New Orleans makes the oak staves for which she is famed.

To the north of Louisiana, the State of Arkansas yields a large quantity of valuable hard and other woods; and, crossing the Mississippi river, the comparatively untouched woods of Tennessee cover an area of more than 10,500,000 acres, thus exceeding the timber-bearing area of Michigan, Wisconsin, and Minnesota combined. The bulk of the Tennessee forests are situated in the east of that State, and teem with woods of the more valuable kinds, such as oak, ash, poplar, cherry, hickory, and black walnut, of large dimensions and superior quality.

From the above considerations it is quite evident that but the fringe of the pitch pine region of America has yet been touched by the axe, and that our consumers will be able to procure their requirements at a reasonable price for the next twenty years, even if the Northern States should likewise claim a portion to eke out their own resources.

The relation of steam ocean carriage on the pitch pine trade to Europe will be most beneficial, as it will enable the goods to be delivered in prime condition. It is not unlikely that a larger portion of pitch pine will arrive in a sawn state than heretofore, but the removal even of hewn logs will probably sooner or later be effected by steam, when the trade develops sufficiently to make the building of suitable vessels remunerative. On the other hand, the specific gravity of the wood militates against its being carried long distances by rail, and this circumstance alone will exercise a not unimportant restrictive influence on the consumption of the wood in the treeless regions of the States that are inaccessible by water. The circumstance that pitch pine thrives best on soil comparatively worthless for agriculture gives an assurance of continuous crops from the "pine barrens" of the Southern States.

The forests along the New Northern Pacific Railway, from Montana eastward to the Jacko river, comprise red fir, tamarac, cedar, yellow pine, etc., and many of the trees are over seven feet in diameter at breast-height, and of proportionate altitude. These supplies, which have hitherto been inaccessible, owing to want of communication, will be of great service, not only to the settlers of the district, but also enable a large saw-mill industry to grow up for the benefit of other less-favoured regions.

Again, the wonderful forests of red fir, pine, cedar, and oak, in the Puget Sound district of Washington Territory on the Pacific coast, have been characterised as the finest in the world. That the quantity is enormous may be inferred from the fact that the amount available reaches upwards of 260,000,000 loads. The fir is frequently found growing to a height of 225 feet, with a straight and well-proportioned bole of 80 feet to the first limb, being twenty inches in diameter at the latter height. There are about thirty mills in the district, mostly belonging to San Francisco firms, with a sawing capacity of fifty to seventy St. Petersburg standards each per day. The export in 1881 from Puget Sound was 290,295 loads of sawn wood. This was sent south, principally to the Pacific States of the Union and Australia. Only the edge of the forests has been penetrated so far, and it will probably be two generations before the ground has been denuded of the original growth.

GERMANY.

Most of the wood bought from Germany is shipped at Memel, Königsberg, Dantzic, and Stettin in the Baltic provinces. Memel, on the Russian frontier, is a town almost exclusively dependent on the timber trade for its prosperity, seeing that about 80 per cent. of the outward-bound vessels carry wood. The comparative importance of Memel for British timber-consumers was greater formerly than it is now; about fifteen years ago the annual value of rough timber arriving from Russian Poland being about £750,000, while it is less than £500,000 at the present time. This diminution has probably been caused to some extent by the partial exhaustion of the most accessible timber in Volhynia (Russia), and the increase of local demand, but much more by the fact that the merchants in the producing district find it to their advantage to divert large quantities of the timber to the river Dnieper for transmission to Odessa. Considerable parcels of oak staves and wainscot logs have been thus lost to the Memel export of late years.

The movement of the Memel trade for the last few years can be seen from the following :—

		Reg. tons.		
In 1878	the tonnage loaded was	135,955,	valued at	£552,405
,, 1879	do.	148,386,	do.	508,875
,, 1880	do.	140,190,	do.	544,850
,, 1881	do.	124,565,	do.	500,340
,, 1882	do. approx.	158,000	do.	609,650

Of these quantities Great Britain takes usually above the half, consisting of oak staves, wainscot logs, and hewn or sawn fir timber. Recently the export of sleepers has been considerable, and bids fair to become an important item in the future.

The redwood and whitewood is usually received from Russia by water in a rough state, and sawn at Memel by steam saw-mills. Formerly the converting was performed by windmills, but these have now been discarded. The Memel redwood timber has a good reputation for durability, and it is, perhaps, in spite of its sappy nature, one of the best weight-bearing softwoods in existence. Memel deals can likewise be much more carelessly handled, with respect to stacking, without running the risk of such damage as pitch pine would be liable to suffer if used in the same way. In competition with pitch pine, however, Memel hewn timber is not likely to hold its own, nor is an enhanced supply of either oak or softwood, with the possible exception of sleepers, to be looked for, when the hostile disposition of the Russian Government to the development of the frontier Prussian towns is borne in mind.

From Königsberg and its outpost Pillau, sleepers, and a few cargoes of hewn timber and pit-wood, are received, but the same obstructions to the development of the trade exist here as obtain at Memel.

Our import from Dantzic and Stettin consists principally of oak planks, hewn oak logs and staves, red and whitewood square balks, sleepers, and pit-props. The quantity of these goods shipped to this country from Stettin in 1883 was 61,562 loads out of a total export of 85,402 loads, and comprised about 30,000 loads of hewn oak logs, 15,000 loads of square redwood balks, and 14,000 loads of props and small birch and alder.

The exports from Dantzic to Great Britain are about double those from Stettin, and there is a larger proportion of sleepers and redwood balks. Considerable quantities of oak staves and planks are also despatched from Dantzic to France. At one time, before the cessation of wood shipbuilding, the relative importance of Dantzic for our timber supply was greater than it is now. For the last ten years, indeed, the wood trade of this port, as well as that of the other neighbouring places, has been either stationary or receding, if the export of small round timber, such as props, pit-wood, birch and alderwood, which has sprung up along the North German coast during the last few years, is excepted.

Notwithstanding the fact that Prussia contains no less than 19,888,300 English acres of woodlands, or 23 per cent. of the whole superficies of the country, under the best forest management in the world, the greater portion of the timber received from German ports is probably grown in Russia. The non-progressive state of our timber import from Germany is due to a variety of causes, of which the following are probably the most important. Among minor causes, the partial exhaustion of the most accessible forests in Russian Poland and Galicia, coupled with the increased local demand both in Russia and North Germany, consequent on an increase of population, may be noted; while, on the other hand, the competition of the pitch pine States in America, the cessation of wood shipbuilding, the obvious desire of the Russian authorities to divert the trade to their own ports, and, above all, the duty placed on the importation of wood to Germany in 1879, have all actively tended to restrict the shipments. It is to be borne in mind that the Prussian State forests cover not less than 6,530,917 English acres, or about one-third of the woodlands. The desire to make this area as productive as possible, and at the same time to afford help to the landowning class in the improvement of their economic position, and in the getting of their estates out of the clutches of mortgagees, are doubtless amongst the more active inducements prompting the authorities to extend the prohibitive import duties now levied on manufactured and planed wood to deals and battens. If this expressed determination be carried out, it will cause a further diminution in the German export trade.

Under the head of Hewn Timber from "Other Countries," there were imported in 1883 no less than 392,831 loads. The bulk of this was doubtless props received from the south of France and north of Spain by the Bristol Channel ports, principally Cardiff, Newport, and Swansea. The quantity obtained from France alone rose from about 66,000 loads in 1871 to 200,000 loads in 1878, and at the present time cannot be much under 250,000 loads. These French and Spanish props are sold by the ton, at a price so low that competition from Scandinavia is out of the question.

In conclusion, it is to be noted that, for the best qualities of Swedish, St. Petersburg, and White Sea redwood deals, battens, and boards, higher prices are likely to rule in the course of a few years than have been paid of late. American yellow pine is admittedly becoming scarcer, the Swedish districts supplying the best goods are being worked as much as they can bear, and St. Petersburg alone is too small to meet any largely increased demand for her forest products. The region around the White Sea is the only district capable of largely augmenting the output of better-quality redwood, and judiciously planned saw-mill enterprises in that locality ought to have a good future before them.

For the inferior qualities of redwood (Scots pine) and whitewood (spruce), every ground exists for the supposition that both Sweden and Finland are competent to meet a considerably increased call for cheap building timber at a small permanent increase of price. The same is also the case with the Russian Baltic provinces; while, of the products of British North America, Great Britain is likely for many years to come to be one of the most important consumers, although the prices may continue to be pressed down by the competition of kindred woods from the north of Europe. For any deficiency of large balk timber from the north of Europe that may probably occur, the pitch pine ports of America will doubtless provide a full equivalent.

XII.

ON THE BEST METHOD OF MAINTAINING THE SUPPLY OF TEAK, WITH REMARKS ON ITS PRICE, SIZE, AND QUALITY, AND ON THE BEST SUBSTITUTES FOR SHIPBUILDING PURPOSES.

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ANALYSIS OF ESSAY.

Part I.—The Economic Value of Teak Timber.—*Introduction*—Description of the teak tree—Special characteristics of teak wood: (1) Varieties; (2) Weight and strength; (3) Durability; (4) Workability.

Part II.—Maintenance of the Supply.—General review—Our future supplies: (*A*) *Natural forests*—(1) Extending the areas of "reserved" forests; (2) Protection from fire; (3) Coppicing; (4) Replenishing growing stock; (5) "Rab" cutting; (6) Taking teak to market. (*B*) *Artificial plantations*—(1) Raising and working; (2) Choice of soil; (3) Climate and aspect; (4) Extension of the plantation system; (5) Assisted private cultivation; (6) The best method of sowing teak seeds—General measures for maintaining the quality: (1) On the practice of "ringing" or "girdling;" (2) Extracting oil from growing teak; (3) The season for felling; (4) Seasoning the logs; (5) Insect attacks; (6) Care in shipment, etc. Maintaining the size of teak logs—The price of teak timber.

Part III.—Substitutes for Teak Wood.—Admissibility and advantage of new woods—Woods already known, but little used in construction: (1) Greenheart; (2) Mora; (3) African Oak; (4) Jarrah; (5) Tewart; (6) Silverballi. Less-known woods: (1) Champa; (2) Jarúl; (3) Sissoo; (4) Thingan; (5) Nan-ta-roop; (6) Padouk; (7) Angelique; (8) Anan; (9) Peroba-Branca; (10) Pynkado; (11) Sunder; (12) Indian Redwood; (13) Chow. Forest districts for extended working: (1) Brazilian Empire; (2) British Guiana; (3) Malacca; (4) Honduras.

Conclusion.

THE VALUE OF TEAK TIMBER.

In the supply of timber for economic uses all men have an interest, directly or indirectly, and if such be the case, with what great interest must our naval constructors and merchant-shipbuilders watch the maintenance of the supply of such a wood as Indian teak, and examine the merits of new or less-known timbers which may be brought forward to be substituted for it, in, at any rate, some parts of a ship's construction.

It may be safely asserted that, for the purposes of shipbuilding, there is no other wood at present in use which has so many valuable qualities as teak. This is proved by the fact that, with over sixty different woods in "Lloyd's Table A" (exhibiting the number of years to be assigned to the different descriptions of timber used in ships), teak only is classed No. 1, and accredited with sixteen years—a period longer by four years than that assigned to any other wood.

It is not to be understood that by thus referring to "Lloyd's" their standard should be so accepted as to prevent enterprise in bringing new materials of construction into use; on the contrary, "Lloyd's Rules and Regulations" are based upon experience or reliable experiments, and are altered from time to time, as new discoveries are made.

Not only have shipbuilders learned its value as a material of construction, but other important industries in this country now demand a share of the teak supply. Horticultural builders find in it properties peculiarly suitable for hothouse construction, in which the durability of timber is put to a very severe test, and for which the oily nature of teak, and its freedom from shrinking, at once commend it.[1] In railway and other carriage building, too, where iron fastenings are very largely used, teak is much in demand, its essential oil preserving these, instead of corroding them, as do the gallic or tannic acids present in oak and other woods. Vast quantities of teak are also used in India for purposes in which we employ the cheaper woods: rafters, beams, and timbers in houses of the better class, cart-wheels, etc., are made of this wood; and for railway sleepers Dr. Schlich has recently recorded that teak and sal are the favourite woods. It must be remembered, too, that the shipments of teak to Europe from Burmah only constitute about one-third of the total shipments from that country; the remainder being sent to India and elsewhere in the East. During five years previous to 1881, 484,478 loads were transported to Asiatic ports direct from Burmah, and 211,894 loads to Europe. The chief reason for the extensive use of this wood for the above and similar purposes is to be found in the fact that it resists the attacks of the termites or white ants, which greatly destroy most other timbers in tropical countries.

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[1] I am informed that at Glasgow, within the last twelve or eighteen months, an extensive range of hothouses has been constructed wholly of teak. Sufficient time has not yet elapsed to judge of the success of the undertaking. It appears that the vapours condense on the naked wood, and a slimy growth appears. I should imagine that painting or varnishing the wood will prevent this.

Tectona grandis, order *Verbenaceæ*, belongs to the class of hard, leafy, non-resinous, and non-coniferous woods. It is a deciduous tree, found principally in India, but from the southern limit of its range in Java it is distributed over about 2000 miles, almost touching the 23d parallel of north latitude. Its range in longitude is also very considerable, since it is found to stretch across Hindustan, and through Burmah, almost to the frontier of China.[1] Gamble says[2] that its northern limit may be defined by a line passing from the mouth of the Nerbudda, up that river, and across to and down the Mahanadi, but that in some places it extends further north, and is to be found as far as Jhansi, and Bander, being cultivated in Assam, Bengal, and the sub-Himalayan provinces, as far north as Saharampur. The most extensive, and probably the best, forests of teak at present existing are in Burmah, where they extend along the banks of the Salween, Thoungyeen, Irawaddy, and other rivers; they also stretch very far inland to the countries occupied by the Shans, the Karens, and the Chinese. It is moreover believed to be plentiful in Siam and on several of the islands of the Indian seas.

The teak-tree seems to require a minimum mean annual rainfall of 30 inches, but to thrive best with a mean annual rainfall amounting to from 50 to 120 inches. It is of straight and lofty growth, with copious spreading branches, and is remarkable for its large drooping leaves and cross-armed panicles of showy white flowers. It frequently attains the height of 80 or 100 feet, with a circumference varying from six to ten feet, yielding timber in the log, from twenty-three to fifty feet in length, and from ten to thirty inches square, these being the sizes commonly shipped to this country.

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[1] Laslett, *Timber and Timber Trees*, 1875, p. 112.
[2] *Manual of Indian Timbers*, 1883, p. 283.

Plate I. gives a general idea of the majestic proportions of this noble tree; and Plate VI. shows clearly the leaf, flower, seed-pods, and sections of the seed.

The two kinds best known for trade purposes are the Malabar and the Burmah teak. The former grows in the teak forests along the western side of the Ghaut and adjoining mountains, where numerous streams afford water-carriage for the timber, and the largest forests are upon the Anamallay Hills, from 1500 to 3000 feet above the level of the sea, which however at present consist chiefly of saplings and trees past their prime.[1] In districts where the climate and soil are favourable, teak seems to have once grown in the forests over the greater part of India, though at the present time a sufficient quantity is not grown even to supply the local requirements of the Government services and the needs of the population. In 1877-78, 20,030 tons of teak were imported into India from Burmah; and during the seven years ending 1881-82 the average annual import into Madras alone of teak from Burmah, amounted to 9554 tons.[2] Teak is more generally found in the Central Provinces[3] than any other tree. It forms an essential part of the forests throughout the Satpuras and Vindhyans; it is less frequent in the Maihal range of hills, though occurring in Mandla and Balaghat. It is also found throughout Bhandara and Chanda.

In Burmah the two principal ports for the shipment of teak are Moulmein and Rangoon. In the Moulmein markets at least five kinds are sold, and at Rangoon large quantities are brought down the Irawaddy, and sold under the name of Irawaddy teak. Siam also has lately contributed a considerable quantity[4] to the British market.

Special Characteristics of Teak Wood.—In colour and lustre the wood of the teak-tree resembles oak; it is light, easily worked, and, though porous, is strong and durable. It requires

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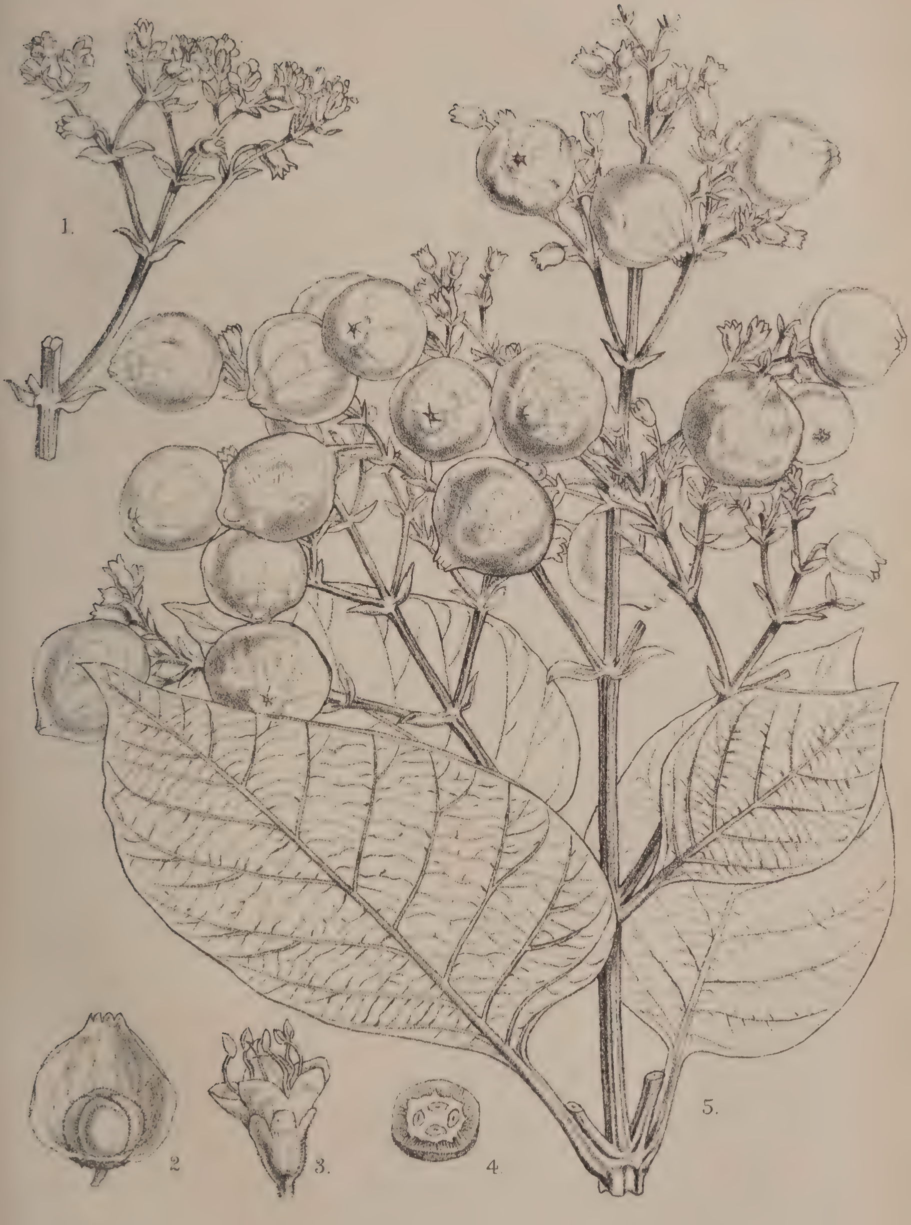
[1] Laslett, *Timber and Timber Trees*, 1875, p. 118.

[2] Dr. Brandis, *Suggestions regarding Forest Administration in the Madras Presidency*, 1883, p. 240.

[3] Dr. Schlich, *Suggestions regarding Forest Administration in the Central Provinces*, 1883, p. 4.

[4] The Customs Returns for 1882 show that 949 loads of teak were imported from Siam.

Pl. VI.



TECTONA GRANDIS, *Linn. fil.*

Reduced from Brandis' Ill. Forest Flora.

Fig. 1. Stem with Flowers. Fig. 2. Longitudinal Section of Calyx enclosing Fruit
Fig. 3. Single Flower. Fig. 4. Transverse Section of Nut. Fig. 5. Stem with Leaves and Fruit.

little seasoning, and does not shrink much. Being of an oily nature, the wood does not injure iron.

Although imported and known under the general name of teak, there are many varieties, if not distinct species of it, the Burmese naming those found in their country after the districts in which they grow;[1] thus—

A. *Moulmein District.*

Variety of Teak.	Character.
1. Thoungyeen, 2. Salween, .	Yellowish-brown in colour; smooth and uniform in texture; with a fine long grain. Transverse strength 284 lbs. (specimen of the Thoungyeen).
3. Karenee, . .	Alternate shades of dull brown and yellow colour; grain close and long, occasional figure; very free from defects. Transverse strength 271 lbs.
4. Attaran, . .	Rather stunted in growth, but of somewhat greater circumference; brownish in colour; dense, hard, and very much like Malabar teak; heavier, coarser, and more knotty than above-named varieties; defects not infrequent. Transverse strength 201 lbs.
5. Laingbooe, . .	Peculiar growth, having stems twisted and deeply grooved or fluted, taking a tree of large size to yield a small, straight, square log, and that only indifferent, owing to twisted fibre; colour dark; wood hard and heavy. Transverse strength 175 lbs.

As to the transverse strengths given, "the specimens tried when in Burmah were 2″ × 2″ × 84″, supported on props 6 feet apart, with the weight applied, as usual, in the middle, the result being that the Thoungyeen and the Attaran both broke with a long splintery fracture, while the others snapped off very short."[2] The mean strength from the above experiments would be 233 lbs. per square inch.

B. *Rangoon District.*

Variety of Teak.	Character.
Irawaddy, . .	Pale yellow in colour; closely resembling Thoungyeen in uniformity of texture, and in having a long, straight grain; wood clean and free, but having the central commonly softer and more spongy than the outer layers; shaky at centre—specially a fine star-shake; does well for backings to armour plates, etc., when used in bulk, but cannot be converted into planks and boards without incurring a very considerable loss. The trees are straight, and yield a better average of log than those of the Moulmein district. Transverse strength undetermined.

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[1] *Timber and Timber Trees*, 1875, p. 116.

[2] *Ibid.* p. 119.

C. *Malabar District.*

Variety of Teak.	Character.
Malabar, . . .	Very good in quality, but generally darker in colour, denser, heavier, and stronger than Burmah teak, though of less flexibility, and not so easily worked. The teak grown on the Anamallay hills is subject to extensive heart and other shakes about the centre of the tree, and on this account the trees are much less useful.[1]

It will thus be seen that the quality of the timber depends very much upon the locality in which it is grown, and that it is exceedingly variable. The recorded experiments on the weight and strength of teak, to which we shall now allude, further illustrate this latter statement.

Weight and Strength of Teak Wood.—Gamble,[2] taking an average of over fifty experiments by different authorities, gives the weight of teak at approximately 40 lbs. per cubic foot, and the value of the constant "*P*" for transverse strength at 600.[3] Captain J. C. Dundas, V.C., R.E., in his report on experiments made at Lucknow in 1877 and 1878, in which the weight of teak is given at 34 lbs. and *P* at 470 as an average, says that logs received at Lucknow show a weight of nearly 50 lbs. per cubic foot, but that after being well dried and sawn into scantling, the average weight falls to 34 or 35 lbs. His value for *P* is a reliable one, for it is based on experiments made with beams of the large size of 10′ 0″ × 6″ × 4″.

	Modulus of Elasticity.[4]	Cohesive Force.[5]	Transverse Strength.		Compression.	
			Stiffness[6] "a."	Strength[3] "P."	Flexure.	Crushing per Square Inch in Lbs.
English Oak, . .	1,714,500	12,000	·0119	557	2068	6,484
Indian Teak, . .	2,167,074	15,000	·0076	717	2614	10,081

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[1] *Timber and Timber Trees*, 1875, p. 118.

[2] *Manual of Indian Timbers*, 1883, p, 292.

[3] According to Prof. Roorkee Papers, April 1879, vol. viii., No. 32, $P=\frac{WL}{BD^2}$, where W=breaking weight in lbs.; L=length (clear span) in feet; B=breadth in inches; and D=depth in inches.

[4] Weight in lbs. per square inch required to extend the piece to double its original length.

[5] Cohesion of a square inch in lbs. The experiments were made by pulling specimens of the woods asunder in the direction of their length.

[6] Supposing Δ =the deflection in inches, then $\Delta=\frac{L^3\times W\times a}{B\times D^3}$.

The preceding selection of constant numbers for the strength of beams and pillars of oak and teak is given for comparison. The numbers are stated[1] to be based on experiments made by the most eminent authorities.

The specimens used appear to have been of small scantling, and of a quality superior to that which would be found throughout the whole substance of a large beam.

Teak wood, according to some authorities, does not split easily; but this appears to be true in a limited sense only, *i.e.* when the force is applied so as to separate the fibres very gradually. It will however split when brought into use unless care is observed in applying the fastenings,[2] and formerly an objection was made to its use in ships of war on account of its liability to splinter if struck by a shot. It has been noticed too that when indiscreetly used for purposes where it was subjected to a strain of this nature, as in the cheeks of gun-carriages under fire, it has suddenly given way by splitting.

Durability of Teak Wood.—The length of time which teak wood is said to have lasted, under favourable circumstances, is quite marvellous. In the Museum at Kew Gardens there is a specimen of perfectly sound teak, received from Salsette in Bombay, supposed to be 2000 years old.[3] Teak wood rib-lining of the arches in the caves of Karli is said to be coeval with their construction about 2000 years ago; and Pliny states that the beams in the Temple of Apollo at Utica were in perfect preservation in his day, though they had then endured 1178 years.[4] It has been considered by many that a ship built of this sort of wood may remain seaworthy for a period varying from thirty to fifty years. The old Milford Bombay ship, in the country trade of India, was the oldest and best-conditioned ship that ever came under Mr. Edge's notice. She was, he says, built of Malabar teak about thirty-five years before he saw her; she had been constantly at sea, and only had a small repair during that period.

Gamble thinks that the durability of teak is due to the aromatic oil contained in the wood, and almost all the authorities concur in this view.

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[1] Barlow, *Strength of Timber, etc.*, and Hurst, *Tredgold's Carpentry*, pp. 55, 58, 117.

[2] Laslett, *Timber and Timber Trees*, 1875, p. 113.

[3] *Official Guide to Kew Museum*, 1883, p. 104.

[4] *Cyclopædia of India*, 1873, Art. "Teak."

In regard to the ravages of wood-destroying animals, it bears a very favourable comparison with most other woods. As already noticed, it is one of the few woods which the white ants will generally leave unmolested. The essential oil with which it is impregnated probably checks their ravages, as they have been known to eat it when old, and after prolonged exposure to the air. I have been informed by an old Indian officer that he has thrown into an ants' nest a piece of Calicut teak, and that after being left there some time it had been taken out and examined, and found uninjured, the surface being merely scratched.

Laslett,[1] on the other hand, remarks that many teak logs are worm-eaten, holes from a quarter to half an inch in diameter being found upon the surface, and often penetrating deeply and in all directions. Such logs have generally a dull appearance, and are invariably brittle and of inferior quality, and he believes that this defect is indicative of an unhealthy if not dead state of the tree before it was cut down.

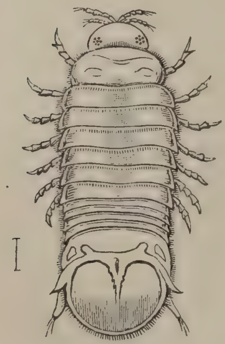

Fig. 2.
Limnoria terebrans (magnified).

Teak and greenheart are the only known woods used in shipbuilding that are said to be proof against the attacks of the *Limnoria terebrans* (Fig. 2), a marine animal which resembles in appearance a very small woodlouse, and causes much damage to many timbers, which in course of time assume the appearance represented in Fig. 3. Sometimes, however, teak is attacked by marine worms—probably by the *Teredo navalis*, the most common enemy of wood used in submarine work. Fig. 3 shows the appearance of this animal and of the wood after its attacks.

Workability of Teak Wood.—When the wood is newly cut into scantling, it is easily worked, but after some exposure the resinous oil present oozes into and congeals in the shakes and open pores, forming there a hard concrete substance which no edge-tool can touch without losing its keenness. By carpenters it is often thought to be gritty, but such is not the case, as the above reason sufficiently accounts for the rapid loss of edge which their tools so frequently undergo.

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[1] *Timber and Timber Trees*, 1875, p. 122.

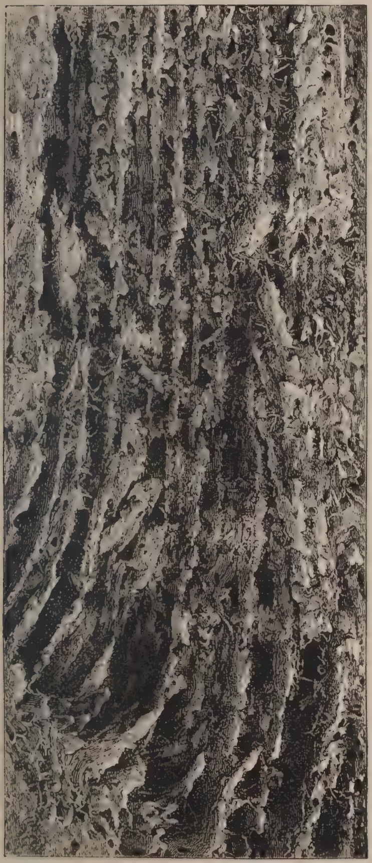

FIG. 3.—Wood bored by *Limnoria terebrans*. (Engraved from a photograph.)

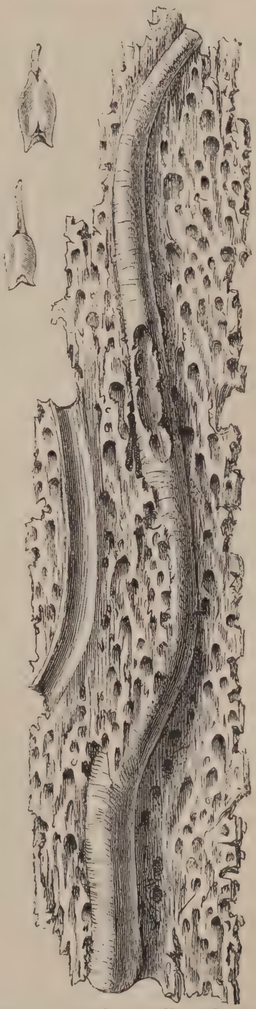

FIG. 4.—*Teredo navalis* and wood bored by it. (After Forbes and Hanley.)

Barlow and others have published the results of experiments showing the amount of shrinkage, and the loss of weight of teak during seasoning. These do not, however, furnish many data for purposes of comparison with other woods, especially those grown in this country, as teak, having come from a great distance, and consequently a considerable time having elapsed since felling, is seasoned to a considerable extent when it arrives here. It may be noted, however, from these experiments, that a piece of teak from the butt end of a tree four feet long and twelve inches in diameter, when first imported weighed 41 lbs. 6 oz. per cubic foot, and that after seasoning it had lost in weight 5 oz. per cubic foot, the dimensions, however, remaining *exactly* the same. Another piece, cut from the top end of a tree, measured $4' \ 6'' \times 6\frac{1}{2}'' \times 6\frac{1}{2}''$, and weighed 43 lbs. per cubic foot when first imported, but after seasoning it was found that the piece had not shrunk at all, although it had lost in weight at the rate of 13 oz. per cubic foot.

When once seasoned, teak does not crack, warp, or alter its shape. This is a very valuable quality for wood used in shipbuilding, considering the various conditions of exposure to which a vessel is often subjected during her voyages from one part of the globe to another, perhaps within a comparatively short period enduring the great heat of a tropical sun and the icy cold of a Polar region. On account of its fixity of form under exposure to the sun, photographic printing frames are now being largely made of this wood.

As already indicated, the property of preservability which teak possesses is extremely important, inasmuch as metal fastenings are prevented from corroding by reason of its oily nature. There are very few other timbers known which have this quality, though many otherwise useful woods contain acids which directly *assist* corrosion.

MAINTENANCE OF THE SUPPLY.

In considering this question we must not forget that although there is a general outcry that the supplies of teak are running short, it is a fact that pretty regular supplies have been kept up for a number of years despite the frequent assertion that the teak forests would soon be exhausted. Going back to 1863,[1] we find that British imports of this wood were as follows:—

From Sierra Leone,[2] .	678 loads.	Value per load, £11 0 0 =	£7,459
,, India, Singapore, and Ceylon,	33,872 ,,	,, ,, 11 19 3 =	405,238
,, other parts, . .	334 ,,	,, ,, 11 18 1 =	3,989
Total loads, .	34,884	Total value, .	£416,686

For the year 1882 the imports of teak wood are given thus:—

From Siam, . . .	949 loads.	Value per load, £14 6 8 =	£13,603
,, British India, Bengal & Burmah	39,862 ,,	,, ,, 12 16 7 =	511,476
,, other countries,	341 ,,	,, ,, 13 1 10 =	4,465
Total loads,	41,152	Total value,	£529,544

Two principal reasons may be given for the continued supply: *first,* the discovery and working of previously unknown or neglected forests; and *secondly,* the admirable administrations of the India Forest Department, by which the valuable woods have been conserved and protected. It is certainly a matter of great regret, considering the importance of teak timber to England as a maritime nation, that the preservation of the teak forests was so long disregarded.

In regard to the discovery and working of new forests, little explanation is demanded. Perhaps the most conspicuous instance occurring in late years is that of the opening up of the Siam districts. More than ten years ago it was predicted by Laslett that if a careful selection of the logs were made at Bangkok "good shipments might be made for the London market."[3] That this opinion was well founded there can be no doubt, the import table given above showing that in 1882 the value per load of the teak from this source was higher than that of teak from any other place; from which it may be inferred that its quality was of a superior kind.

With reference to the second point above referred to, namely, forest conservancy in India and Burmah, a brief outline, with special reference to the teak forests, is all that can be given here.

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[1] Official Customs Returns of British Imports and Exports.

[2] This was probably African oak, *Swietenia Senegalensis*, or *S. Khaza*, as teak proper does not grow in Africa. The two woods have often been confounded.

[3] Laslett, *Timber and Timber Trees*, 1875, p. 113.

In 1805, the Bombay Government for the first time laid claim to the indigenous forests of the western coast of India, and appointed Commissioners to fix their boundaries, a proclamation being issued in 1807 to assert the Company's right of sovereignty. From this date *an attempt* at conservancy was made, but it failed in its object, and about 1822 all the restrictions which had been imposed were removed. This course, however, led to still more disastrous results, which threatened the speedy and complete destruction of the forests themselves. The question was again pressed upon the attention of Government, but so many were the difficulties in establishing a system of conservancy, which would not infringe upon private rights, that it was not until 1846 that the Forest Department was organised.[1] It was necessarily some time before the officers of the Department could be put in practical charge of their respective districts, and the work of demarcation carried out, and even when this was done, many of the so-called "reserved" forests were so only in name. The Forest Department was at first organised in the Bombay Presidency, under Dr. Gibson, mainly with a view to insuring supplies of timber for the dockyard.[2] In the following year, 1847, the question of forest conservancy was first raised in the Madras Presidency, by Major-General F. C. Cotton, C.S.I., then a captain in the Madras Engineers, who, in crossing the mountains which divide Coimbatore from Cochin, was surprised at the wasteful manner in which the contractors for the supply of teak to the dockyard at Bombay were working the forests, which they rented from the Collector of Coimbatore. These men having access to the neighbouring private forests of Cochin, and of the Kolumgode Humbidy, had the free run of the Anamallay Hills, which were then almost unexplored. General Cotton accordingly urged on the Government of Madras the advisability of taking these forests into their own hands, and working them through their own agents; and on his recommendation Colonel (then Lieutenant) Michael, C.S.I., was appointed to carry out the experiment.

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[1] Dr. Cleghorn, *Forests and Gardens of South India*, 1861, p. viii.

[2] Markham, *Moral and Material Progress of India*, 1872-73 (published 1874).

Colonel Michael, first under the direction of General Cotton, and afterwards of the Collector of Coimbatore, organised an establishment, opened roads throughout the lower Anamally Hills, formed timber-slips down the mountain passes, and soon scored a financial success.[1]

In 1848 the Kolumgode Humbidy was induced to lease his forest for sixteen years (the lease having been since renewed in perpetuity), and the minor leases were bought from the timber merchants, thus making the proper conservancy and systematic working of these forests practicable.

Within a few years the advantages of these and similar measures were so clearly seen, that the Court of Directors, in their despatch of 29th March 1854, while fully recognising the success of the work, sanctioned their application to the other forests in the Madras Presidency.

About this time, 1855, Colonel Michael having suffered in health from seven years' incessant exposure in forest pioneering, was obliged to retire from his appointment, and was succeeded in it by Surgeon-Major Hugh Cleghorn, M.D., who carried out the extension of the new department in Madras and the Punjab with astonishing vigour and the most distinguished success. Subsequently, after the arrival of Dr. Brandis in India, Dr. Cleghorn most efficiently co-operated with him in introducing and systematically working conservancy in Bengal and elsewhere.

The Forest officers were soon overwhelmed with troublesome work, on account of the depredations of the many contractors for railway sleepers. The first railway was commenced in India about 1850, and the most exaggerated notions got abroad of the profits that were to be realised by selling sleepers to the railway companies. In consequence of this, every petty timber-dealer in the locality of projected lines began to speculate in sleepers. Unlimited credit in liquor was given to the Gonds, Bheels, Koorloos, Koles, Khoonds, and other tribes who inhabit the forests of the great central plateau which stretches across

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[1] Sir George Birdwood, *Society of Arts Journal*, vol. xxx. p. 478 (17th March 1882).

India from east to west, between 15° and 25° of north latitude; and before the Government could become aware of it, these skilful woodmen had succeeded in felling almost every mature teak-tree along the whole extent of this vast range of country. Hundreds of thousands of valuable trees which never could possibly have been converted into sleepers were cut down. The consequence was that the annual forest fires, passing unchecked over the hills every year, consumed the felled timber little by little, and when the first Conservancy officers were appointed, they found nothing but the charred remains of these logs to indicate where extensive forests had once overshadowed the head-springs of the Mahanadi and Nerbudda.[1]

In Dr. Cleghorn's first annual Report as Conservator of Forests in the Madras Presidency, dated 1858, he mentions the marvellous changes produced by the progress of the railways on the face of the country as regards tree vegetation. He says, "The encircling hills, formerly crowned with timber, are now to a considerable degree laid bare. The changes, so far as I can learn, have been the gradual result of unrestricted cutting, but much aggravated during the last few years in connection with the enormous demand for railway sleepers, etc."

As regards forest conservancy in Burmah, it is to be remarked that, when the Tenasserim Provinces were ceded by the king of Burmah, under the treaty of Zandaboo, they were considered so unproductive that their surrender was at one time seriously contemplated, although it is stated that for many years before the cession of Arakan and Tenasserim in 1826, Burmah had been a great timber-exporting country.[2] Almost immediately after the close of the first Anglo-Burmese war, the forests of the Tenasserim Provinces were examined by Dr. Wallich, whose first Report, referring to the Salween forest, to the north of Moulmein, was dated 1827. The Government, guided by Dr. Wallich, directed that the forests should be reserved as State property, and that an attempt should be made to work the Attaran forests on Government account. Moulmein was then little else than a cantonment and a fishing village, and the timber had to be sent for sale to Calcutta. This did not pay, and in 1829 the Attaran teak forests were thrown open to private enterprise on a licence system. The keen competition which now ensued among European and native traders led to indiscriminate felling of the most valuable timber, threatening speedily to exhaust the forests. The liberty which was accorded to those holding licences, to appropriate to themselves, under most liberal conditions, the unoccupied forests, contributed in the first instance to the prosperity of Moulmein, but it also tended to the extermination of the finest teak. From this time to the period of the second Anglo-Burmese war in 1852, many changes were made in Forest management, ending in the annexation of the lower portions of the valleys of the Irawaddy and the Tsit-toung. Almost immediately after this annexation all the forests were declared to be Government property. In 1856 new rules were published, the Pegu forests were then for the first time brought under regular conservancy, and the destruction of the teak forests to some extent prevented. These rules were revised in 1859, and in 1862 they were extended to the Arakan, Tenasserim, and Martaban Provinces.[1] From this year, says Sir George Birdwood,[2] when Dr. Brandis, then Conservator of Forests in Burmah, was appointed Inspector-General of Forests by the Government of India, forest conservancy dates.[3]

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[1] Sir George Birdwood, Appendix D, "Forest Conservancy in India," in Report of Royal Commissioners on Paris Exhibition, 1878.

[2] *British Burmah Gazetteer*, vol. i. p. 113.

The various isolated establishments which had previously been formed in Burmah, the Central Provinces, and Oude were now consolidated under Dr. Brandis. There were at this time also Conservators in Madras and Bombay, while in the North-West Provinces the special charge of the forests had been confided to the Civil Commissioners of Meerut and Kumaon. These latter officers were rather timber agents than conservators, and though some good was effected by them in the way of regulating the felling of timber, it cannot be said that the proper work of forest conservancy was anywhere undertaken or even understood by them. Dr. Brandis took his stand on the principle that the main object of forest conservancy in India was to preserve, not to cut down, the forests, though he made it clear, and has since proved, during the twenty-one years of his administration as Inspector-General of Forests, that the Forest Department could be self-supporting.

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[1] *British Burmah Gazetteer*, vol. i. p. 115.

[2] Appendix D, Report of Royal Commissioners on Paris Exhibition, 1878.

[3] The names of Cotton, Michael, Cleghorn, and others have already been mentioned as pioneers in Conservancy work.

Our Future Supplies of Teak.—Guided mainly by our experience of the past, we will review our prospects, and offer suggestions, under the two following divisions—(*A*) The conservation, working, and improvement of natural teak forests; (*B*) The raising and working of artificial plantations, etc.

(*A*) *The Conservation, Working, and Improvement of Natural Teak Forests.*—With reference to altogether new districts, attention may be directed to Siam, Java, and the islands of the Indian seas, about the teak forests of which comparatively little seems to be known. Carl Bock, however, has quite recently published an account of his travels in Upper Siam and Lao, and in describing the country around the river Mekong, 1500 miles from its mouth, near the town of Kiang Tsen, he says:[1]—"In the country known as Komaw, on the left side of the Mekong, and extending to the borders of Tongking, lie a series of hills and valleys, clothed with magnificent forests of teak, and endless varieties of gum-yielding trees, which would, if properly worked, be a source of enormous wealth. A careful survey of the country to the east should be made, to discover, if possible, a water-route shorter than that down the Mekong, along which the timber could be floated to the coast." Carl Bock also speaks of the marked favour which the king of Siam has already shown to European enterprise, and it is to be hoped, therefore, that he will be induced to see the wisdom of the proper conservation and working of his forests. Something might also be done towards the protection of the valuable teak forests from the ravages of fire, which during March and April often consumes, in addition to unfelled trees, thousands of sawn logs. These forests are leased almost exclusively, where they are worked, by British-Burmese subjects, from the Princes who have a monopoly of the right to cut them. In the teak forests around Chengmai, the labourers mostly employed are men belonging to a hill tribe called Komaws, living to the eastward beyond the Mekong river. These men are hired, as a rule, for a period of three years, and receive as wages the magnificent sum of about eighty rupees (£7, 8s.) a year. The purchasers of teak logs inland assume one standard for the measurement of the length and thickness of the logs; but at Bangkok the measures vary, according to the whim of the purchaser. It is manifest that a uniform system ought to be adopted, and that uniformity ought to be supported by Government enactment. Until this is done, trade must obviously be hampered, and fraud will be encouraged.

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[1] *Temples and Elephants*, by Carl Bock, p. 336.

The soil of Upper Siam, from Bangkok to Raheng, is alluvial, and of great fertility, while, as a whole, "Siam is considered, for the tropics, a healthy country." In the Komaw country, far up the Mekong, where the teak is so abundant, the climate is much more temperate than that of Siam, "owing to the height of the land, which gradually rises from 700 feet at Chengmai to 1200 feet at Muang Fang, but diminishes again to 1150 feet at Kiang Hai, and 870 feet at Kiang Tsen." The temperature at Kiang Tsen is frequently as low as 50° at eight o'clock in the morning.

In regard to natural forests in India, it is difficult, even with the aid of official reports and returns, to get even an approximate idea of their extent and teak-producing capability. There appears to be at present something like 46,000 to 50,000 square miles of forest under Government conservancy in India and British Burmah; but as to the extent of the forests not yet demarcated, and under the control of the Government, it is impossible to speak. The series of forest maps prepared at the Forest School at Déhra Dun, and showing the progress made during the last fifteen years in the demarcation of forest reserves, etc., will make clear, better than figures can, what has been done, and perhaps will indicate what remains to be done.

Again, as to the amount of teak timber which may be extracted annually from well-regulated forests, it is only possible to speak very approximately. In a general way, however, it may be stated that in natural forests, where teak is associated with bamboos and other trees, the number of first and second class trees (*i.e.* of trees above 4 feet 6 in. in girth) rarely amounts to ten trees per acre over large areas. The following are instances of forests exceptionally well stocked with teak:[1]—

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[1] Gamble, *Manual of Indian Timbers*, 1883, p. 291.

Date of Survey.	Forest.	Area surveyed.	Number of Trees per Acre.		
			Class.		Total.
			I. Girth above 6 ft.	II. Girth from 4½ to 6 ft.	
1876,	Bhimaram, . .	50 acres,	4·0	4·3	8·3
1870-71,	Pegu, . . . (Prome District).	17 sq. miles.	3·6	3·0	·6

Teak does not grow in large continuous masses, but is diffused throughout the general forest, in the proportion of about one to five hundred of other trees.[1] In what are called the Teak Forests, strictly speaking, it is found in the proportion of about one to three hundred, not equally diffused, but confined to certain localities of small extent, where it constitutes the prevailing tree for a few hundred yards, seldom for a mile continuously. The seeds are produced after the rainy season, and are contained in a hard shell (see Plate VI.), which requires both considerable moisture and heat to decompose. The teak-tree, therefore, loses nearly a whole season in its propagation, and in its early stages is at great disadvantage in the struggle for existence with the luxuriant jungle undergrowth, and with other giants of the forest, whose seeds are almost invariably shed at the commencement of the rainy season, and sprout almost immediately on reaching the ground.[2] One season's exposure to the sun, night dews, and occasional showers of rain, would be sufficient, one would imagine, to destroy the seed. This, however, is not the case, for seed that must have lain for years under such conditions has germinated after exceptionally high floods.[3] Teak, it is also said, does not frequently spring up under shade. The prevalence of other trees therefore over teak is a great hindrance to the growth of seedlings in sufficient numbers to replace those trees which have been removed.[4] All this shows the need of vigilant conservancy and improvement of these important forests.

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[1] *Report on the Teak Forests of Pegu*, 1854, by Dr. M'Clelland.

[2] Lieut.-General Albert Fytche, C.S.I., *Burmah Past and Present*, 1878, vol. i., p. 305.

[3] *Administrative Reports of the Forest Department in the Bombay Presidency* (Sind Division), 1882-83, p. 7.

[4] *Cyclopædia of India*, Art. "Teak."

Extending the areas of Reserved Forests, and bringing them under stricter supervision, seems to be one of the principal measures which might be adopted to increase the output of teak and other Indian timbers.

There certainly exist vast areas of forest and waste lands which might be brought under protection and forest cultivation, upwards of 50,000 square miles, or 32 million acres, of forest and waste in the Madras Presidency alone being at the disposal of Government,[1] although a large extent is claimed by zemindars and other landholders, whose disputed claims should, in the interests of the country, be brought to a final settlement. Of this 32 millions of acres, only 10 millions are assessed. "What then is the final destination of this large area of waste and forest?"[1] Surely a very considerable addition might be made in all the Provinces to the reserved forests.

From Dr. Schlich[2] it appears that, under Act VII. of 1865, "reserved forests" in the Central Provinces extended to 2549 square miles when the "Indian Forest Act" of 1878 was passed, while 16,953 square miles were classed as "unreserved forests." Steps were then taken to declare all the lands of the latter class "reserved forests" under chap. ii. of the 1878 Act, and in this manner an area of 19,383 square miles was put on a satisfactory legal footing. The reservation of the above-mentioned area was not accompanied by any immediate change in their management. The forests which had been "reserves" under Act VII. of 1865 were under the new Act styled "first class reserves" and the remainder "second class reserves," but each of the two classes continued to be managed as before. The chief objects thus realised are that no part of the area can be alienated without the previous sanction of Government, and that no rights can accrue in any of the forests. The first class reserves are managed by the Forest Department, with the view of improving their productiveness as forest estates. They are strictly protected against damage, and more than one-half of the area is also under special protection from fire. Cuttings are, however, permitted in certain parts for the supply of the people and for public works. The management of the second class reserves is in the hands of the Deputy Commissioners, assisted by a staff of forest officers. The protective measures so far introduced into them are of a very simple nature, *i.e.* a few kinds of trees are not allowed to be felled; and the chief objects aimed at in the management of this area are (1) to supply the requirements of the people of the country with as few restrictions as possible, and (2) to raise a revenue. It appears that the boundaries of these reserves are in a very unsatisfactory condition, being, in most parts of the Provinces, undefined on the ground, and in many instances even disputed. The areas, moreover, are frequently cut up by cultivation which has been permitted in them without fixing the limits within which it may be carried on.

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[1] *Suggestions regarding Forest Administration in the Madras Presidency,* 1883, by Dr. Brandis, p. 5.

[2] *Suggestions regarding Forest Administration in the Central Provinces,* 1883, p. 8.

That this is a subject for improvement has been already recognised. The Government of India has on several occasions urged the transfer of further areas from the second to the first class reserves, and the Chief Commissioner, in his review of the Forest Administration Report for 1881-82, considers this a matter the importance of which to the future interests of the country cannot easily be overrated.

As to the manner in which this object can best be attained, it is Dr. Schlich's opinion that, instead of increasing the transfer of further areas from the second to the first class reserves, it would be better to treat all reserves alike, but to permit the Forest Department to declare a maximum of, say, one-half the area "closed blocks," and to treat these in the manner hitherto applied to the first class reserves. When these have been fully stocked by means of protection against fire, and by sowing and planting, they will gradually be opened to cutting, while in the same degree blocks hitherto open will be closed for improvement. In this manner a rotation will be established.

With the opinions of two such eminent authorities as Dr. Brandis and Dr. Schlich before us, as to the possibility of very largely increasing the area of forest management, it may here be interesting to estimate approximately what area of forest under such systematic management would materially increase the supply, and thus perhaps reduce the market price, of teak timber.

If an area of 10,000 square miles of forest suitable for teak growth were found throughout our Indian possessions, including British Burmah, and could be brought under careful supervision and management on the block system, after a few years' protection from fire, grazing, and other injuries, and with assisted reproduction, perhaps there might be a stock of teak-trees which would yield, say, every five years, five teak-trees per acre, averaging 50 cubic feet per tree. If, again, half this area be always closed for improvement, the result would be an area of 5000 square miles, or 3,200,000 acres. This again, divided by the number of years (five) which we have assumed as the period at which fellings might take place in the same blocks, gives 1000 square miles, or 640,000 acres, which, at five trees per acre per annum, would yield an annual supply of 3,200,000 trees, say 3,200,000 loads of 50 cubic feet. As this is ten or twelve times the present annual yield of teak from all parts, ample allowances may be made.

Protection from fire has already been referred to, and in noticing some measures in the management of forests which have been found to influence their productiveness and which should be largely extended, this ranks as one of the most important.

The forest fires are chiefly caused (1) by shepherds, who burn the grass in order to get with the first rains early green crops for their cattle, (2) by the Comari or Dhya-cultivators, (3) by sparks from the torches or cheroots of travellers, (4) by spontaneous ignition due to friction of bamboos, but (5) chiefly by the wilful burning of grass by the hill tribes.[1]

The risk is said[2] to commence about the beginning of March, and to continue till the rains fall in the middle of June.

As to the firing of[3] forests for cultivation by the natives, it is to be remarked that the Comari or Dhya-cultivation[3] is much in favour with the wild tribes all over India and Burmah. It consists in felling and burning portions of the forest in order to sow a crop of coarse grain in the ashes.[4]

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[1] *Forests and Gardens of South India*, 1861, p. 46.

[2] Dr. Schlich, *Suggestions regarding Forest Administration in the Central Provinces*, 1883, p. 57.

[3] This is called also Kumari, Kumri, etc., and in Burmah, Toungya.

[4] Sir George Birdwood, Appendix D, Paris Exhibition Report, 1878.

For this purpose a hill-side is always selected, a space being cleared at the end of the year. The wood, after being felled, is left to dry till the following March or April, and then burned.[1]

The practice of Comari has been admitted to be an evil, and many endeavours have been made to arrest and check it. In some districts, however, this mode of cultivation seems, to the Ghât people, as necessary to their existence in their mountain wilds as fields are to the husbandmen of the plains. In Burmah and some parts of India grants of forest land have been made to these people on the condition of their raising nurseries of teak and other required plants, to be put out on one-third of the area cultivated, and afterwards protected against fire, trespass, or other injury. Remuneration is given (about six rupees per acre), and the soil is rent-free if the conditions are fulfilled.[2] In the three reserves of the Tenasserim circle, Sinzway, Oankangyee, and Dalee, the propagation of teak by the Karens under the Toungya system resulted during the year 1877-78 in the cultivation of 84 acres covered with 26,435 plants, the average number of plants per acre varying, according to the locality, from 267 to 355.

If this rude system of cultivation, with its attendant waste and danger, cannot be entirely abolished, there is no doubt that the next best thing is to have it controlled and regulated by the Forest Department, more especially if the Comari cultivators can be induced to help in the raising of teak and other valuable plantations.

Among other causes of forest fires, it may be mentioned that timber-merchants are said to induce the wild tribes to fire the forests in order to create dead wood. With the view of driving game, and of obtaining firewood for removal in head-loads to sell in villages, forests are fired, by Kathkaris, Thakurs, and Warlis. Thus in Sind the Sháh forest had to be closed during 1882-83 to the retail dealers in firewood, as the Conservator found that they were in the habit of firing the forest in order to kill the young trees, so that they might become dead wood, which alone they are allowed to remove.[1] Nothing but severe punishment of detected offenders will reduce the range of such conflagrations. For many months of the year the jungles are like tinder, and it is physically impossible for a beat-guard to prevent fires over several thousand acres.[2]

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[1] Dr. Cleghorn, *Forests and Gardens of South India.* Extract from *Proceedings of Board of Revenue*, April 16, 1859.

[2] Colonel Peyton, Conservator of Forests, Southern Division Bombay Presidency, *Administrative Report*, 1882-83, p. 7.

It may here be noted that Dr. Schlich[3] considers the desirability of protecting a larger portion of reserve forests without the clearing of boundary or interior lines, and believes that a knowledge on the part of the people that burning could only lead to the closing of the forests against grazing and cutting would secure the desired result.

The first attempt to keep down the forest fires was made in the Central Provinces. This was carried out by Captain Doveton under the orders of Colonel Pearson. The Bori forest, having an area of about 25 square miles, or 16,000 acres,[4] and situated at the south-west angle of the Puchmurri Hills, was selected for the experiment. It was isolated by a broad line cut all round it, and divided also by fire-lines, after the system pursued by the French Forest Department in the south of France and in Algiers.

The system of fire protection generally may shortly be described, as follows:—Wherever the boundary is not formed by a river, precipice, or other natural feature which in itself is sufficient to keep out fire, the forest is cleared to a breadth of from 60 to 300 feet, according to circumstances, partly by cutting and partly by burning. In addition, a certain number of interior lines are cut and burnt, varying in breadth from 10 to 200 feet. Throughout the dangerous season extra fire-guards are employed, who patrol the cleared fire-lines of the protected areas, and who sweep away any inflammable material which may be found on them. The average cost per acre of the area attempted to be protected in the Central Provinces has amounted during the last five years to 2·86 pies per annum, or about ten rupees (19s.) per square mile. From a careful examination of the effects of fire protection, it is evident that the money spent on this branch of forest work has been well laid out.[1]

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[1] W. S. Hexton, Acting Conservator of Forests in Sind, *Administrative Report*, 1882-83, p. 6.

[2] A. T. Shuttleworth, Conservator of Forests, Northern Division Bombay Presidency, *Administrative Report*, 1882-83, p. 17.

[3] *Suggestions regarding Forest Administration in the Central Provinces*, 1883, p. 18.

[4] Sir George Birdwood, Appendix D, Paris Exhibition Report, 1878.

In the Bori forest the cost of fire protection since 1864 has amounted to about eight annas (11d.) per acre, and the result is that a very valuable stock of teak poles, representing a very much higher value than what has been spent on fire protection, has been successfully raised.[2] The beneficial effects of this plan have been more marked than was even anticipated, for the long rank grass which formerly grew in the forests, and which was the great cause of danger from its inflammability, has everywhere given place to a finer and shorter grass, which burns less readily, while a rich vegetable mould is gradually being formed on the hard burnt crust of earth which formerly existed, and consequently throughout these fire-protected forests a sufficient crop of young seedlings is everywhere springing up.[3]

Of the forests under protection from fire in the Central Provinces, the Ahiri and Jagmandal show in a marked manner the beneficial effects.[4] The former has been partly protected since 1872, and partly since 1875, at an expenditure of fourteen annas (1s. 7d.) per acre, and young teak-trees of great value are now growing vigorously. Similar results are also to be seen in the Jagmandal forest, which has been protected since 1867 at a cost of twelve annas per acre.

Failures, however, have sometimes discouraged the foresters, as shown in the statement below, but on the whole the results are highly satisfactory, and the system of fire protection should be largely extended as a means of increasing the fertility of the forest, and the growth and supply of teak and other valuable timbers.

The following table gives the result of fire-protection in the Central Provinces during the last ten years, as far as they can now be traced:[5]—

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[1] Dr. Schlich, *Suggestions regarding Forest Administration in the Central Provinces*, 1883, p. 17.

[2] Dr. Schlich, *ibid.* p. 18.

[3] Sir George Birdwood, Appendix D, Paris Exhibition Report, 1878.

[4] *Suggestions regarding Forest Administration in the Central Provinces*, 1883, p. 17.

[5] *Ibid.* p. 17.

Year.	Area in Square Miles.		Percentage of Failures.
	Area attempted.	Failures.	
1872-73	226	...	...
1873-74	259	...	...
1874-75	333	...	...
1875-76	629	86	14
1876-77	809	20	2
1877-78	1,097	199	18
1878-79	1,171	91	8
1879-80	1,293	174	13
1880-81	1,444	85	6
1881-82	1,413	204	14

Average per cent. of failures per year during the last seven years, 11.

The Coppicing of Teak.—Another important measure in connection with the working of natural teak forests, and one which has received considerable attention, is the cutting down of badly-grown teak-trees, with the view of obtaining fresh and well-grown shoots from the stumps.

Throughout the forests of the Central Provinces, and doubtless most other parts, large quantities of teak saplings and poles of inferior quality are met with. These have either suffered from the effects of fire, cutting, or other causes, and they are not likely to yield good timber. Under these circumstances, a commencement was made, as early as 1866, to cut such inferior poles and saplings flush with the ground, and to let the stumps send up fresh shoots. The material obtained by these cuttings has been sold, and it has realised considerably higher sums than the cost of cutting and stacking it. To prevent the young shoots from being injured, it is necessary to have some shelter on the ground, which frequently may be given by cutting only some of the trees, leaving the others to act as nurses until the crowns of the new shoots have got above the frost region.

Dr. Schlich says[1] that taking into consideration the great improvement effected by these measures, there can be no doubt that the cutting should be steadily continued in fire-protected areas. These operations have been carried out in many forests, but only the following need be noted:—Punassa (Nimar), Rajaborari, Satpura (Seoni), and in the East Peneh range. In all these cases the results have proved satisfactory.

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[1] Dr. Schlich, *Suggestions regarding Forest Administration in the Central Provinces*, 1883, p. 22.

The cuttings should be made early in the season. In the Sind those that were made late in the season of 1882-83 partially failed, for the shoots had not time to attain a sufficient height before the floods covered the stools and killed them.

Careful felling is an important point. To secure improvement, fellings should in all cases be made flush with the ground, and "on the same plane as the inclination."[1]

The Replenishing of the Growing Stock of Teak Forests.—A great deal of information has been published in the various Forest Reports and elsewhere as to the relative value of the different systems by which reproduction may be carried on. Dr. Brandis is in favour of the more elaborate systems of cultivation, and thinks that in the end it will generally prove to be the more economical.[2]

Major Doveton is in favour of trying broadcast sowings on a large scale. It seems to have the advantage of economy in the first instance, the only expense being the collection and scattering of the seeds, which requires neither skill nor heavy outlay. This is a great advantage in districts where the difficulty of procuring labour is considerable. Thus in 1882-83, in the Ahmednagar District, Northern Division of Bombay, the cost of broadcast sowing over an area of 12,673 acres was only Rs.33 : 8 : 4 (£3, 1s. 6d.), and the results accomplished are said to "exhibit very good effects in some places."[3]

In addition to broadcast sowing may be mentioned "dibbling" into shallow pits or into unprepared ground by the sides of water-courses; sowing in lines or patches; transplanting from nurseries;[4] or sowing into bamboo baskets, which when the plants are about a year old are carried into the forest and deposited in the soil along with the seedlings. In 1875 the last-named method was very successful in the Moharli forest. The seedlings were planted into the baskets in July and August, and were thus sufficiently strong to resist the dry season. The baskets were then planted out in July 1876, and only a very small percentage of the seedlings died. The same method was tried in 1876-77, but owing to the early cessation of the rains, and to the hot dry weather of September, October, and November, a large proportion failed. Some risks to which seedlings thus treated are exposed may here be referred to. These are—(1) the liability to the attacks of white ants to which the baskets are subject; (2) the increase of evaporation resulting from a circulation of dry air round the baskets; and (3) destruction by grubs or wild pigs.

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[1] Mr. Shuttleworth, Conservator of Forests, Northern Division Bombay Presidency, *Forest Report*, 1881-82, p. 29.

[2] Appendix B, Dr. Schlich's *Suggestions, etc.*, 1883, p. 40.

[3] *Forest Report*, N. Div. Bombay Presidency, 1882-83, p. 20.

[4] See under "Artificial Plantations," p. 356.

The Cutting of Trees for Ráb (*leaf manure*).—In some districts of India the rayat declares that without this commodity he cannot exist or cultivate his land, and, according to the system at present in vogue in some parts of the Bombay Presidency, the rayats are allowed not only to lop the teak on their own holdings, but also twenty-eight kinds of trees and bushes in the Government forests.

That the constant clearing away of the young growth, so useful for the protection of the soil, has a most pernicious effect is beyond doubt, and may be seen by any one who will compare the growth of the teak forests where the undergrowth has been cut for Ráb with that in the more remote parts which are beyond the reach of such treatment.[1]

Although in some cases much good may be done to forest trees by permitting the lopping off of the branches of the less valuable wood,[2] it may be said generally that the practice of cutting for Ráb should be watched and controlled.

It may here be mentioned that, according to Dr. Falconer,[3] elephants do not injure young teak, as it belongs to a family (*Verbenaceæ*) that affords no fodder for animals.

The Method of taking Teak from the Forest to Market.—In Burmah, three years after girdling—a process still carried on in this region, and one to which we shall subsequently refer—the trees are felled, marked, and dragged by elephants to the bed of the river or stream which drains the forest. Here they are left till the waters rise during the rains, when the logs float down, in some cases untouched and unseen, in others, as in the Thoungyeen, followed and guided by men and elephants. When they reach the "Kyodan" their further progress is artificially arrested. Parties of foresters here recognise their own timber by the marks put on in the forest, draw each log to the bank, and form them into rafts, which are taken down the stream by raftsmen to the Government timber station, where they must be deposited, entered on the forest revenue books, and duty—if due—paid before they can be taken further down to the sawpits or to the ships waiting to receive them for export.

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[1] Colonel Peyton, Conservator of Forests, Southern Division Bombay Presidency, *Administrative Report*, 1882-83, p. 21.

[2] Appendix B, Dr. Schlich's *Suggestions, etc.*, 1883.—Dr. Brandis, p. 41.

[3] *Cyclopædia of India*, Art. "Teak."

At the Kyodan on the Salween, some distance below the great rapids, where the river is between two cliffs narrowed to one-third its natural breadth—a deep, blue, clear, swift stream running between them—an immense cable is stretched from one side to the other to intercept the floating logs as they are carried down by the current.

At dawn a number of foresters may be seen scrambling over, diving under, or swimming amongst the logs, now and again shouting with laughter as a rolling log precipitates a novice into the water, each trying to select one for the purpose of paddling it ashore clear of the assembled mass.

Sometimes the pressure of the collecting timber snaps the cable, and the whole mass, including drift and rubbish from the forest, is carried down the river till it is stranded by the current, or with great difficulty landed by practised men who make this their profession, and receive pay for salvage according to a fixed scale.[1] Some of the escaped timber, however, is often lost by being carried out to sea or stranded on unfrequented islands. The salvors are also busily employed in collecting such logs as accidentally pass the rope; these they form into rafts, from which the owners subsequently select their own logs.[1] It seems a pity that some improvement on this state of matters cannot be effected to prevent loss of valuable teak, and danger to still more valuable life.

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[1] On the Salween, 5715 teak logs were salved in 1876-77, and 4384 in 1877-78. The aggregate result financially in both the Tenasserim and Pegu Circles for 1877-78 was: Receipts, Rs.68,950, and Expenditure, Rs.40,716. *Forest Report*, 1877-78.

In South-West India rafts are formed by binding the logs together by the stringy bark of various trees—strong branches being passed through drag-holes at right angles to the logs. A hut made of bamboo laths, and covered with palmyra leaves, is often built on the rafts in order to shelter the floaters at night, at which time the rafts are fixed in deep water by tying them to a tree growing on the adjoining bank.[2] Water-carriage is everywhere resorted to whenever available, being obviously the easiest and cheapest possible. Generally speaking, the custom of floating timber in rivers and docks injures it very much, partial immersion being the worst situation in which it can be placed. It is better, when possible, to completely sink the logs under water.

(*B*) *The Raising and Working of Artificial Plantations, etc.*—Although the artificial sowing, planting, and rearing of teak has engaged the attention of the Government authorities in India for a considerable number of years, the practical results of the Plantation system are only beginning to be known, and it appears that its further extension on a grand scale would largely aid in maintaining the supply of teak timber.

Great praise is doubtless due to the officers of the India Forest Department for their perseverance in the work of artificial reproduction and cultivation, when the repeated failures in first experimenting might have altogether put a stop to this now promising field. At the same time, when it is remembered that probably only about seventy square miles in all our Indian territory is under such cultivation, there is evidently plenty of room for extension in the vicinity of navigable rivers, and in localities where railway communication can be commanded. It should not be overlooked, however, that the extension of communication is making rapid strides in advance, and that a locality which now appears inaccessible may become well connected with ports of shipment and other parts of the country, after the lapse of a comparatively small number of years.

[1] *British Burmah Gazetteer*, 1879, vol. ii. p. 603.

[2] Dr. Cleghorn, *Forests and Gardens of South India*, 1861, p. 14.

Dr. Schlich reported,[1] so recently as last year, that in the Central Provinces sowing and planting operations so far undertaken were all of an experimental nature, and that where planting was done systematically, and the planted areas looked after for some years, success had been obtained, as, for instance, in the Satpura Reserve, but where a more rough system was tried the results were disappointing,

In Burmah the subject of artificially increasing the amount of teak timber, instead of trusting wholly to its natural reproduction, has long received the attention of those interested in the question, but it was not until recent years that the labours of the Forest Department met with success in this direction.

In 1842 experimental plantations were formed in the Attaran valley, but there were no satisfactory results. In 1843 another and equally unsuccessful experiment was made near the Hlaing-bhwai river. Nothing further was done till 1856 when about 40 acres of land near the mouth of the Theng-gan-nee-noung stream, in the valley of the Weng-raw, were planted, but the work was abandoned owing to the insalubrity of the climate, the distance of the plantation from Moulmein, and the difficulty of procuring labour. In 1857, however, an experimental plantation was formed on the west bank of the Irawaddy, a short distance below Prome, and, blanks having been filled up and its area increased, it covered in 1880 about 66 acres. Between 1858 and 1865 smaller plantations were established in the Rangoon, Henyeda (then called Mzanoung), and Shive-gyeng Districts, and the total area under experimental cultivation was thus made up to rather over 121 acres. Since then regular plantations have been formed and kept up, covering an area of 1716 acres in the Rangoon forest division, 766 acres in the Tsit-toung forest division, 73 acres in the Prome forest division, and 17 acres in the Salween forest division, up to 1879. According to orders which were issued about 1879, plantation work is to be concentrated in the Rangoon forest division, and carried out in the other forest divisions to a limited extent only, in addition to the work done by such hill-garden cultivators as will assist by planting teak in their gardens, for which they receive remuneration from the Government in various ways, direct and indirect.

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[1] *Suggestions regarding Forest Administration in the Central Provinces,* 1883, p. 21.

In fact, until about 1868 little was done in Burmah to assist the reproduction of teak, but since then, up to 1879, an area of 3066 acres has been cultivated in Government plantations, and another area of 1341 acres under Major Seaton's teak hill-garden system.[1]

In India proper, so early as 1804, Colonel Gilbert superintended the formation of small teak plantations at Honore, Ankola, and Sidashegur, in the Madras Presidency. Dr. Cleghorn,[2] who visited them in 1857, reported unfavourably on the growth of the trees, which had been planted on unsuitable soil and in an exposed situation.

The Nilambur teak plantations in Malabar, commenced by Mr. Conolly in 1843, and since added to yearly, have, perhaps more than any other, proved how successful such work may be, when proper care is exercised in selecting a locality as regards soil, climate, and other natural conditions, and especially when trained foresters are employed for sowing and rearing purposes during the earlier years of growth. The total area stocked at Nilambur is 3436 acres, of which 1787 are stocked with a full crop on alluvial soil, the rest not being expected to yield so large a produce.[3]

Choice of soil for Teak Plantations.—The soil most suitable for the growth of tall and straight teak-trees is undoubtedly the alluvial, except when it is low-lying and wet; in that case it is said to produce a lighter, coarser-grained wood, containing an acrid oil which affects iron very materially.[4]

It seems to thrive best "on a moderately stiff loam with free subsoil drainage, such as results from the decomposition of trap."[5]

In Burmah the upper mixed forests, which are the principal seat of teak, and might therefore be called *par excellence* the

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[1] *British Burmah Gazetteer*, 1880, vol. i. p. 124.

Dr. Cleghorn, *Forests and Gardens of South India*, 1861, p. 10.

[3] Gamble, *Manual of Indian Trees*, 1883, p. 290.

[4] Leonard Wray, in Paper read before the Society of Arts, May 4th, 1859 (*Society of Arts Journal*, vol. xxi. p. 427).

[5] *Suggestions regarding Forest Administration in the Central Provinces*, 1883, p. 3.

Teak Forests of Burmah, occupy exclusively the soft sandstone formations of the Pegu Roma, and also the older strata of the hills to the eastward. Forests occurring on the latter formations differ a good deal from those found on sandstone, not only in their general growth, but also by an admixture of trees which do not occur on the sandstone; while on the Pegu Roma the teak-trees attain an average height (especially on the higher and drier ridges) of about 120 feet, those found on syenitic and schistose sub-strata seldom exceeding 80 to 90 feet in height, and the growth of their clean stems being never so straight and regular. In other words, the soft sandstone produces lofty, while metamorphic rocks yield only big trees.[1]

Very exact data regarding teak plantation work has been recorded by Colonel Beddome in his Report on the Nilambur Plantations (1878). He says that the trees grown on gneiss and laterite show a much slower rate of growth than those on alluvial soil, and that there is a considerable difference in height, but much less in girth.

The following measurements, extracted from this Report (par. 11-44) illustrate these statements :—

Nilambur Plantation.—Alluvial Soil.			Nilambur Plantation.—Gneiss and Laterite.		
Age.	Mean Girth, breast-high.	Total Height of Tree.	Age.	Mean Girth, breast-high.	Total Height of Tree.
3-7 years.	12 inches.	29 feet.	7 years.	13 inches.	30 feet.
13-17 ,,	23 ,,	68 ,,	16 ,,	14 ,,	50 ,,
18-22 ,,	25 ,,	71 ,,	20 ,,	21 ,,	50 ,,
23-27 ,,	27 ,,	77 ,,	24-26 ,,	22 ,,	52 ,,
30 ,,	35 ,,	85 ,,	30 ,,	24 ,,	52 ,,

In another part of his Report (par. 81), however, he gives data which would seem to show that the average size of the trees in the older plantations, *all on alluvial soil*, is considerably greater.[2] He there states the diameter of the largest, smallest, and medium-sized trees in four plantations (*i.e.* consecutive years' planting), the result being as follows :[3]—

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[1] *British Burmah Gazetteer*, 1880, vol. i. p. 88.

[2] Gamble, *Manual of Indian Timbers*, 1883, p. 286.

[3] The first three lines show the average of six trees in each case, and the last line the average of eight trees each. It is distinctly stated that the length of *bole* is given, and not that of the entire tree.

Age.	Mean Girth (probably breast-high).			Length of Bole.		
	Largest.	Medium.	Smallest.	Largest.	Medium.	Smallest.
30 years.	67 inches.	47 inches.	29 inches.	79 feet.	65 feet.	50 feet.
31 ,,	69 ,,	49 ,,	30 ,,	80 ,,	65 ,,	50 ,,
32 ,,	63 ,,	46 ,,	30 ,,	83 ,,	67 ,,	50 ,,
33 ,,	68 ,,	56 ,,	43 ,,	86 ,,	68 ,,	50 ,,

Up to ten years of age, the growth in length of teak on alluvial soil at Nilambur is at the rate of about six feet per annum, later on it is only one foot per annum.

The above figures also testify that it probably attains half its height, with a girth varying from 2 to 3 feet.[1]

Thus the trees grown upon alluvial soil, having a girth varying from 25 to 35 inches, are from 71 to 85 feet high; and from all that is known regarding the growth of teak in similar localities, it is probable that, unless damaged by storms, disease, insects, or other causes, it would attain a height of 150 feet in soil of this description, and in the climate of Nilambur.[2]

Climate and Aspect for Teak Plantations.—It has already been stated that the teak tree seems to require an annual rainfall of at least 30 inches, but that it thrives best with a mean annual rainfall varying from 50 to 120. This should be carefully looked into in choosing the sites for new plantations.

The aspect of the proposed site is another important consideration. In Burmah, teak is said[3] to grow best on the southern and western slopes of the hill forests, where it is exposed to a strong sun. On the open and exposed ridges is becomes scarce, and it disappears altogether on the northern sides of the hills. Its peculiar partiality for the southern and western slopes, together with the time of year it seeds, renders the distribution of teak discontinuous and limited in the natural forests.

This partiality for a southern aspect seems to be exhibited in a tabulated statement of valuation surveys, made in the year 1876 by Mr. Thompson, of some parts of the Bhimaram forests.[1] It will be seen from the following abstract that the southern parts are much better stocked with teak-trees than the northern half:—

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[1] *Forest Flora of North-West and Central India*, p. 358.

[2] Gamble, *Manual of Indian Timbers*, 1883, p. 287.

[3] Lieutenant-General Albert Fytche, C.S.I., *Burmah Past and Present*, 1878, vol. i. p. 303.

Central Provinces, Bhimaram Forest.	Number of Teak Trees per acre.				
	1st Class, diameter 24″, and upwards, breast-high	2d Class, diameter 18″ to 24″, breast-high.	3d Class, diameter 12″ to 18″, breast-high.	4th Class, diameter 6″ to 12″, breast-high.	Total.
Northern half, . . . (78 acres surveyed.)	2·410	1·718	3·153	6·089	13·370
Southern or hill part, . (50 acres surveyed.)	4·00	4·28	7·48	8·30	24·06

Low-lying ground by river banks, etc., where frost is likely to be severe, should be avoided.

In the two small plantations made in the Bori forest in 1868, Dr. Brandis[2] noticed the damage which frost had done to the plantation at the low level on the bank of the river, as compared with the higher ground near the edge of the standing forest,—a marked difference in point of size as well as of regularity in the appearance being at once observable.

Extension of the Plantation System.—Judging from the *known practical results of artificial plantations*, there seems every encouragement largely to extend the system under judicious management.

A few years after the time of planting, an income is derived from thinning, etc., which pays the expenses of management. Thus it is stated in Dr. Cleghorn's Report for 1859,[3] that thinnings of the Nilambur teak plantations, the oldest then only sixteen years of age, were advertised for sale, and readily purchased, as they were admirably suited for fencing, scaffoldings, roofing to second-class houses, and other economic purposes, as well as for poles for country carts, yokes, and the like.

Hence although at first there is considerable outlay, the thinnings soon repay the expenditure, so that the trees left for timber are "almost clear gain."

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[1] Dr. Brandis, Appendix B; Dr. Schlich's *Suggestions, etc., Central Provinces*, 1883, p. 54.

[2] Dr. Brandis visited the Bori forest in the winter of 1876. *Ibid.* p. 38.

[3] Dr. Cleghorn, *Forests and Gardens of South India*, 1861, p. 41.

To determine the number of trees and growing stock per acre of plantations, sample areas of half an acre were selected in seven plantations at Nilambur, each tree was measured, the cubical contents determined, with the following results :—

Name and Year of Plantation.	Age of Plantation in years.	No. of Trees per acre.	Average length of Bole in feet.	Mean gross Girth of trees in inches.	Cubic contents in cubic feet.		Average annual increment in cubic feet.	
					Per tree.	Per acre.	Per tree.	Per acre.
Iravelly-Kara, 1844, .	33	120	59	9·7	41	4,879	1·2	148
Elanjerry, 1845, .	32	158	61	7·9	30	4,742	0·9	148
Do., 1846, .	31	156	60	7·4	27	4,204	0·9	136
Moolathamanoo, 1847,	30	140	62	7·5	27	3,713	0·9	124
Do., 1848,	29	156	60	6·8	21	3,243	0·7	112
Elanjerry, 1858, .	19	270	45	5·0	8	2,203	0·4	116
Wallashary, 1868, .	9	750	40	3·4	3	2,491	0·4	277

It is not expressly stated, but Gamble thinks it probable, that these sample areas were all selected on alluvial soil.

Colonel Beddome[1] estimates that, on alluvial soil, the teak at Nilambur will reach maturity at from sixty to eighty years, that fellings will be spread in each plantation over fifty years, and that when the mature trees are cut down (say at an age of eighty-five years), the mean quarter girth will be 2 feet; the length of bole will be 70 feet; and the mean contents of each 280 cubic feet. He also estimates that at that age there will only be 60 trees to the acre, making the contents per acre 16,800 cubic feet. In his estimate of the future value of the plantations, Colonel Beddome only assumes 6000 cubic feet per acre as the full crop expected on alluvial soil. No speculation, however, can with safety be formed.

Taking an average of 4000 cubic feet, or 80 loads per acre as the full crop eventually, it appears that if 500 square miles, or 320,000 acres, could be cultivated in yearly plantations extending over 1-85th of that area (= 3765 acres), a permanent rotation system might be established, which would yield, when in full working order, at 80 loads per acre for the full and final crop, something over 300,000 loads of teak timber per annum ; that is to say, more than seven times the total quantity (41,152 loads), imported into Great Britain during 1882.

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[1] *Report on the Nilambur Teak Plantations*, 1878.

There is no doubt that failures must be allowed for ; but with all allowances, there seems to lie open to the Government a very tempting field in the further extension of teak plantations.

Assisted Private Teak Cultivation may be noticed as a branch of the plantation system. It has been tried, and in some parts, where the natives are led to see that the interests of the Government and themselves are identical, good results have followed.[1]

Dr. Cleghorn[2] at an early date (1859) suggested that, to relieve the expected future pressure that was *already* being felt, on account of the enormous demand for railway sleepers by railway companies, as well as by irrigation companies, sugar factory proprietors, and others, who consume large quantities of fuel, charcoal, and timber, these companies should plant to some extent, for their own use, in station compounds, along railway embankments, on the banks of channels, and elsewhere. If a sufficient inducement were offered by Government much might be done to encourage private landowners to cultivate teak and other valuable woods, and thus augment the supply, at least for home consumption.

It is interesting to note that in Canada, where the question of the best means of promoting tree planting and forest preservation is now exciting considerable interest, one proposal, having special reference to Ontario, is said to be meeting with general favour. If this proposal were adopted, a farmer would be encouraged to reserve five, ten, or fifteen acres of his land in forest by a Government enactment freeing such portions of his property from taxation, but rendering him liable for all taxes whenever he ceased to preserve them. But the principle is the same, whether in India or Canada; and now that the secrets of successfully raising young teak are being found out, no time should be lost in widely making the best use of those means which lie nearest at hand and are available without elaborate preparation.

As to *the best method of sowing teak seeds* so as to insure germination, many interesting experiments have been made, and much information published from time to time. Mr. Conolly, then collector of Malabar, made many efforts at Nilambur, about 1840, to ascertain the best means of propagation in order to establish the teak plantations.[1] The tahsildar, who advised Mr. Conolly to prepare the seed, had come to the conclusion that those which germinate in the forests lost their outer coating by the great heat caused by the fires which annually consumed the brushwood, and that perhaps this process should be imitated as closely as possible in artificial sowing. Accordingly this was tried, but proved unsuccessful, as the kernel appeared in most cases to be injured by the heat, though a few germinated. The nurseries were visited about this time by M. Perrottet, a French botanist, who suggested that the seeds should be placed in a shallow box, successive layers of earth composed of vegetable manure and seeds filling up the box. This mass was to be frequently watered for forty days, by which time it was expected the seeds would germinate, when they should be carried to suitable spots in the forest (for M. Perrottet condemned nurseries on separate ground for the purpose of teak plants), and placed in couplets or triplets in holes of about two inches at the deepest, and slightly covered with earth. Dr. Wight suggested to Mr. Conolly that before planting, teak seeds might be treated like cinnamon seeds, *i.e.* gathered together in a heap, covered lightly with straw or fern, and kept moist until germination began ; or that they might be thrown into nearly boiling water, 180° or 200° Fah., and left there until the water cooled. Mr. Graham, the Sub-Conservator, being convinced that the shell ought to be cleared of the spongy coating before being put into the ground, had 6000 so cleared with the knife and sown in beds, when not less than 4000 germinated. Mr. Graham also discovered that white ants could be usefully employed in thus clearing them, and thought that in the natural forests it was only those seeds which were so cleared which germinated. He recommended that nurseries should be formed at a distance from water and on the clearest ground that could be found, in order to avoid the swarms of insects which, he said, were very destructive to everything newly sprung from the ground.

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[1] The arrangement with the Toungya cultivators in Burmah, as well as Major Seaton's teak hill-garden system, under which an area of 1,341 acres had been cultivated in Burmah up to 1879, have been already referred to.

[2] *Forests and Gardens of South India*, 1861, p. 33.

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[1] *Forests and Gardens of South India*, p. 303.

In the *Cyclopædia of India*, article "Teak," it is said that the best method of raising seedlings is to take fresh stable manure and strew it to a thickness of three inches over the bottom of a trench; then to cover this layer with (*a*) four inches of decaying leaf-mould; (*b*) one inch of wood ashes; and (*c*) about six inches of a light sandy soil, the fine silt from the bed of a tank being the best. The nuts, which are to be previously steeped in water for thirty-six hours, are then sown in holes four inches apart, and are sunk to a depth of half an inch beneath the surface; lastly, the beds are to be covered with straw so as to prevent evaporation, and gently watered every evening. Seeds thus sown are stated to sprout in from four to eight weeks.

GENERAL MEASURES FOR MAINTAINING THE QUALITY OF TEAK.

That much teak of inferior quality is imported into this country from Burmah for use in Admiralty Dockyards, as well as in private works of construction, is well known, and it will be interesting to refer to various considerations that bear on this question. In addition to the influence of soil, climate, and the like, above discussed, the following points may now be taken up:—

(1) *Ringing or girdling.*—There has long existed, and there still exists in some parts, a very general practice, especially in Burmah, of girdling teak-trees three years before it is intended to fell them. The trees are selected and operated upon almost everywhere in British territory by responsible Government officers, a complete ring of bark and sapwood being cut through about five feet from the ground, and removed, in order to kill the tree. This object is very soon attained, as in a few days, or at most in a few weeks, the tree dies.

The custom has been advocated on the ground that the seasoning is thereby expedited, and also that when the dead tree is felled the specific gravity is much less, and the logs can therefore more easily float over the shallows of the streams or rivers to the port of shipment. The first of the above reasons is doubtless only *too* true, as the timber becomes at once dry, brittle, and inelastic.[1] The latter reason is more weighty, although it does not seem to present an insurmountable difficulty, inasmuch as in most of the reserved forests, and in the plantations, the logs could be protected, and kept off the ground for a sufficient time to allow the process of natural seasoning considerably to decrease the weight of the wood.

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[1] Laslett, *Timber and Timber Trees*, 1875, p. 115.

Laslett objects to the practice of girdling, as many fine trees are thereby lost by breakage in falling, and as it shortens the life of the tree unnecessarily,—a consideration of great importance if plantation-work is carried on systematically and scientifically. The process was discontinued in the Anamallay forests on the ground that the heart-shake was caused, or at least extended, by it; but from the Forest Reports it appears that its influence in producing this result is limited, as out of 100 trees felled green 27 had extensive heart-shake, and 10 others were affected less seriously. Again, when a tree has been ringed, the woodcutters object to cut it down on account of its increased hardness.[1]

Mr. Laslett also observes that as the evidence of the utility of girdling goes no further than to show the advantage gained in being able to float the timber immediately after it is felled, it is pretty certain that before long the custom will be abolished. In the recent Forest Report from Burmah it seems that where girdling has been abolished, there is a desire to have the practice again recognised. If the difficulty of transit is really the only objection to felling green trees, it is a pity that this should not be got over, rather than that the quality of the timber should suffer.

(2) *Extraction of Oil from growing Teak.*—This practice is carried on in some parts, where proper supervision has not yet reached and protected the teak forests. The oil is said to be used (*a*) medicinally, (*b*) as a substitute for linseed oil, and (*c*) as a varnish. It is opaque, dull, and ash-coloured. When allowed to rest for some time it separates into two layers,—an upper dark-coloured clear stratum, and a lower and more solid deposit.

The extraction of so valuable a principle from the wood must very seriously affect its quality, and on account of its injurious results it should be prevented wherever discovered.

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[1] Dr. Cleghorn, *Forests and Gardens of South India*, 1861, p. 64.

(3) *Season of Felling.*—The portion of a tree first liable to undergo fermenting changes is the sapwood.

It is to these changes that decay is traced, and it is therefore of very great inportance that the tree should be felled when it contains the least proportion of sap. Deciduous trees such as teak indicate this season by their naked appearance, and evergreens by the ripening and falling of their fruit.

Laslett[1] carefully examined and compared a great many pieces of both winter and spring or summer felled logs, and found almost invariably that the winter-cut timber, after being a few years in store, was in better condition than that which had been cut during spring—both having been under similar treatment for preservation. The winter-felled logs were sounder, less rent by shakes, and the centres or early growth generally showed less of incipient decay than the spring-felled. This refers to deciduous trees generally, and to British oak in particular, but it is a valuable practical record bearing upon the principle involved.

Another very important consideration is that teak should be felled when there is the least proportion of sapwood to heartwood, or, in other words, when the tree is at maturity. The proportion of sapwood to heartwood varies according to age. In mature trees there is no sapwood. It is also to be borne in mind that the teak-tree is subject to a wasting away of the early annual layers long before it reaches maturity. The number of young teak found thus affected in the rafts brought from the forests to the shipping ports is very remarkable, though the surveyor, judging only from the deliveries of teak in this country, would hardly be aware of this, as hollow trees would not be selected for the European market.[2]

There is a notion among woodcutters that trees should be felled during the wane of the moon, but nothing has been brought forward to demonstrate the advantages of so doing.

(4) *Seasoning the Logs.*—If left, after being felled and trimmed, to the scorching heat of the sun and to the blast of the hot winds, the external fibres of the wood, being first exposed, contract, and as there is no corresponding shrinking of

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[1] Laslett, *Timber and Timber Trees*, 1875, p. 314.

[2] *Timber and Timber Trees*, 1875, p. 122.

the central fibres, cracks and splits are the result. The logs, when placed under cover, should never be so enclosed that they cannot be exposed to a free current of air. They should be kept off the ground by supports of brick or stone, and the ground should be strewn with ashes or cinders to prevent the growth of grass or fungi. The ends of teak logs, which are very liable to split, should be covered up with grease, mud, petroleum, or matting.[1] It is of the utmost importance that the sap should be allowed to diffuse out freely.

(5) *Insect Attacks.*—The many insects which prey upon Indian forest trees perhaps effect more injury than all the other sources of decay, and immersion of the logs in a solution of bichromate of potash or other mineral salts according to Boucherie's process, might be valuable as a remedy.[1] Many teak logs are worm-eaten, holes from a quarter to half an inch in diameter being found upon the surface, which often penetrate deeply and in all directions.

If the timber is liable to be attacked by insects or worms while it is in the form of logs, the preservation of the wood should be begun as soon as possible. There are now many well-known preservative compositions in the market, and if the need is admitted, something of this nature might be tried.

(6) *Care in Shipment, etc.*—Much timber is injured by carelessness or ignorance in shipment, and it ought to be recognised that proper ventilation is absolutely necessary. The timber brought from America in the heated hold of a ship is invariably covered over on being landed with a complete coating of fungus,[2] especially if the cargo has been shipped in a wet condition, and the voyage has been a long one.

Teak is certainly not so liable to these dangers as yellow pine, red pine, or oak, but all possible care should be taken and dangers guarded against.

Many systems of ventilation, such as "Banner's" and "Boyle's" are now applicable to ships, so that there is no excuse for carelessly packing away valuable timber in a close and heated hold.

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[1] Dr. Cleghorn, *Forests and Gardens of South India*, 1861, p. 65.

[2] *Encyclopædia Britannica*, Art. "Dry-rot."

THE MAINTENANCE OF THE SIZE OF TEAK TIMBER.

For many years it has been difficult to procure teak scantling of large size. In 1860 Dr. Cleghorn,[1] in his third report, as Conservator of Forests, on forest operations in the Madras Presidency, stated that teak scantling of large size was becoming more and more scarce all along the west coast, and that in Malabar *first-class logs* were not easily procurable. In favourable situations the teak-tree grows to a sufficient height to furnish the lower masts for ships of 2000 tons burthen, and it is commonly employed for this purpose in the East Indies. It is naturally a tall tree, and greater lengths might be produced from it than are generally received, if only a little more care were taken to prevent waste in the forests.[2] In the late contracts for this description of timber for the Royal Dockyards, it was stipulated that the minimum length of the log should be twenty-four feet and the average twenty-eight feet; but as of late it has been found difficult to obtain this average from the Moulmein district (whence nearly all our supplies have been drawn for many years past), the minimum and average lengths have been reduced to twenty-three feet and twenty-seven feet respectively.

Regarding waste in the forest we may note (1) the practice of laying the axe to the trunk one yard from the ground; (2) diffuse hacking over a broad surface—an unnecessary loss of timber now prohibited by enjoining contractors and forest employés to cut within a foot and a half of the ground;[3] and (3) the cutting off of the bole or stem below the branches, while, by including some of the knots of the lower branches, a gain in length and in value could easily be secured.[2]

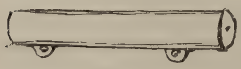
Fig. 5.

Before the Forest Department began their work some most reckless practices existed in the forests, namely, that of forming "drag-holes" (see Fig. 5), and that of trimming the logs so that they might fit carts in length and width,[3] a practice which may still be prevalent at a distance from check and control, or where there are peculiarities of tenure and few facilities of communication. The former defect could easily be dispensed with by an improved application of ropes, and the latter has been generally set aside.

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[1] *Forests and Gardens of South India*, 1861, p. 80.
[2] Laslett, *Timber and Timber Trees*, 1875, p. 114.
[3] *Forests and Gardens of South India*, 1861, p. 4.

The Burmese assign two reasons for not aiming to produce a better average length of log. One is that the greater the length, the greater is the difficulty of moving and getting them out of the forests to the streams, and the increased danger when there of entanglement in the short bends of the water-courses; another is, that until a few years ago the long logs were liable to some trifling duty, while upon the short pieces coming from the forests no charge whatever was levied on their arrival at Moulmein.[1]

Now that the reserved and protected forests and plantations are under strict supervision, with trained woodmen, and with modern science to design the most suitable carriage and gearing, there should not be such a dearth of full-sized teak logs and long masts in the years to come.

THE PRICE OF TEAK.

Complaints have often been made that the cost of first-class woods is high, and that the supply is not at all times equal to the demand. It is therefore very desirable to know how the supply can be largely increased and the cost considerably diminished.

This cheapening may be effected by opening up new sources of supply, as well as by taking greater advantage of those which are already open to us.

Methods by which the supply can be largely increased have already been pointed out; and if the Government is content with a fair profit, this large increase should materially affect the price, especially if the teak forests of Upper Siam and other parts, which are almost unknown as to extent, are successfully opened up and brought into competition.

It is interesting to notice how greatly teak has been in demand since the beginning of the century, and how much the price has risen; although, considering the length of time during which the forests were neglected, it is a wonder that the supply has been kept up so well.

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[1] Laslett, *Timber and Timber Trees*, 1875, p. 114.

In Milburn's *Oriental Commerce,* 1813, vol. i. p. 328, we find the following statement: "Teak timber, of an ordinary quality for shipbuilding, sells at nine or ten rupees a candy, which measures 15¾ English cubical feet; the foot therefore costs from 1s. 6d. to 2s. Choice timber sells as high as Rs.16 a candy, or 1s. 10d. a cubical foot."[1]

In the Forest Report for Bombay Presidency, 1882-83, attention is directed to the price of Dáng teak of the larger size in the coast markets. Thus:—

In 1880-81,	price of teak per khandi of 12½ cubic feet, was 12 rupees.				
,, 1881-82,	,,	,,	,,	,,	14 ,,
,, 1882-83	,,	,,	,,	,,	17½ ,,
,, 1883-84, probable	,,	,,	,,	,,	20 ,,

All the cost of felling, removing from the forests, and carriage to the coast (40 miles), in addition to the price paid to the Forest Department, being borne by the purchaser.

In the London market the value of teak has fluctuated very much. In 1859 and 1860, the market being overstocked, it stood as low as £10 to £11 per load of 50 cubic feet, but in 1861, when there was a sudden and unexpected demand for timber generally, it rose to £16 per load; it soon, however, declined again, and was in 1875 to be had for about £12 or £14 per load. In the Official Custom Return of Imports for 1882, the value of British India, Bengal, and Burmah teak is given at £12, 16s. 7d. per load, and that of Siam teak at £14, 6s. 8d. per load. At present the trade journals give the price at from £15 to £17 per load.

If the conservancy and regulation of the forests in India is carried out on an extended scale, there is every reason to believe that the market price will be kept down. The published financial results of the working of the forests in the Central Provinces prove that the profits increase approximately in proportion to the extent of the area controlled and the work done.

By arranging the receipts and charges of the Forest Department in the Central Provinces in periods of three years, the following averages per year are obtained:[2]—

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[1] Extract in *Forests and Gardens of South India,* 1861, p. 80.

[2] Dr. Schlich, *Suggestions regarding Forest Administration in the Central Provinces,* 1883, p. 32.

Year.	Receipts.	Charges.	Surplus.	Proportion of Surplus to Receipts in per cent.
	Rs.	Rs.	Rs.	Rs.
1864-65 to 1866-67	2,19,682	1,12,971	1,06,711	49
1867-68 to 1869-70	3,72,016	3,27,000	45,016	12
1870-71 to 1872-73	5,29,186	2,62,317	2,66,869	50
1873-74 to 1875-76	6,51,827	3,16,186	3,35,641	51
1876-77 to 1878-79	7,32,699	3,33,344	3,99,355	55
1879-80 to 1881-82	10,09,915	5,05,033	5,04,882	50

From this it appears that "the financial results are in every way satisfactory," and that "the Department can . . . well afford to spend a considerable sum per annum on the protection and improvement of these valuable Government estates."[1]

SUBSTITUTES FOR TEAK.

The aim of the shipowner is to obtain lightness, strength, and durability in the construction of his ships; and whether that object can best be secured by employing one description of timber, or by a judicious combination of several kinds, can only be decided by experiment and strict investigation.

The diverse requirements of a ship's timbering and planking have been compared to the combination of woods employed in the construction of a West-Indian buggy or cabriolet, viz. calabash for the naves of the wheels, brazilletta for spokes, acacia for felloes, cedar for the body, and lancewood for the shafts.

But a comparatively few years ago no wood was thought to equal British oak for shipbuilding, the expression "hearts of oak" implying all that was sound and trustworthy, all other hard and heavy wood in use in the Royal Dockyards being tabulated as "substitutes *for oak*,"[2] and being used in the building of a ship only when some particular degree of lightness or strength was demanded.

It is a great encouragement in the search for "substitutes" to know that at Lloyd's the authorities are ready to acknowledge the merits of new materials, when these are brought forward and satisfactorily tested, and to alter their tables accordingly. For instance, the great value of teak has been emphasised by its now being placed all alone in Class 1, whereas formerly there were eight woods in this class. *Blue gum*, too, has risen in the scale; formerly it was classed with *stringy bark* in the 5th Class, but has now a place in the 3d Class. "That such a body should originate, or even suggest experiments, is entirely foreign to its character and to its vocation; but when independent enterprise has fully tested and proved a case bearing upon the construction of ships, it is then for Lloyd's, acting upon the experience so gained, to adopt and sanction the improvement or alteration if they deem it worthy of their attention."[1]

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[1] Sir G. Birdwood, in a letter to the *Society of Arts Journal* of 17th March 1882, says that the nett revenue of the India Forest Department was, in 1869-70, £158,854; in 1875-76, £274,551; and in 1880-81, £223,000. For last year the nett revenue was about £300,000.

[2] Laslett, *Timber and Timber Trees*, 1875, p. 49.

It is well known that, although the institution of "Lloyd's" was not in any way specially authorised by Government, but is a private body, yet practically shipbuilders and shipowners are entirely dependent upon their surveyors as to the "class" which is assigned to their vessels. Consequently it is not at first to a shipowner's advantage to introduce new materials if they are not recognised at Lloyd's.

It is rather to the Government Dockyards[2] that we must look for experiments carried out on a large scale, as the Crown alone can afford to ignore Lloyd's tables, and bring into use new materials which may prove of great value, not only to the Navy, but to the whole shipping community.

We will first bring forward some woods which have been already tested at home or abroad, and which are specially recommended for special purposes. Several of these woods are already classed high at Lloyd's, but are not so generally used as they might be.

(1) *Greenheart* (*Nectandra Rodiœi*), belonging to the natural order *Lauraceœ*, is found in Guiana, in the north-eastern portion of South America. It is called by the natives "Sipiru," and is

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[1] *Society of Arts Journal*, 1859, vol. vii. p. 428.

[2] Mr. Thomas Laslett, Timber Inspector to the Admiralty, has published, in *Timber and Timber Trees*, accounts of experiments on almost all the known woods. This information is invaluable, Mr. Laslett's opportunities enabling him to state his opinion with authority. His book has been consulted freely, and his opinion is given, where available, upon most of the "substitutes" named.

very abundant within 100 miles of the coast. It is a valuable tree, and yields straight timber from twenty-four to fifty feet in length, and twelve to twenty-four inches square. It is clean and straight in the grain, very hard and heavy, tough, strong, and elastic. The alburnum or sapwood is of a dark greenish colour, and differs but little in appearance from the heartwood, though if it is placed in any damp or imperfectly ventilated situation, it decays much sooner than the heartwood. In quantity the sapwood is usually excessive, frequently amounting to a fifth, and sometimes even to a third, of the diameter of the tree. Few people regard it as of questionable durability when appropriating this timber for works of construction, and many assert that it may, like the sapwood of Lignum Vitæ, be employed with safety, if used under more favourable circumstances than above mentioned. Greenheart is extensively employed in shipbuilding for keelsons, engine-bearers, beams, shelf-pieces, and for planking. It is remarkable both for strength and durability,—in strength exceeding that of most other woods, whether it be tried by the transverse or tensile strain, or by a crushing force in the direction of its fibres. The average weight is 71·82 lbs. per cubic foot, although some authorities assign to this wood a much less specific gravity. In Hurst's *Tredgold's Carpentry* it is put down at 58 to 65 lbs. per cubic foot, and Captain Fowke found the specific gravity of a specimen to be 1·052.[1] The comparative transverse strength, English oak being = 1·000, is 1·652; and the comparative elasticity, English oak being 1·000, is 0·982. With Captain Fowke's experiments, the crushing force in the direction of the fibre of a piece one inch square and one inch high was about 12,000 lbs., and the transverse strength of a specimen nine and a half inches long between the supports, and two inches square, when loaded in the middle, was 15,428 lbs. With respect to its durability, Laslett remarks that in the Royal Dockyards sufficient evidence has been obtained. Here a large stock of the wood is kept, and after exposure for many years to the action of the weather, it has been found to be affected only in the slightest degree.

In the Kelvingrove Museum, Glasgow, there are two pieces of planking from a wreck submerged during eighteen years on the west coast of Scotland. One specimen, greenheart, is merely slightly pitted on the surface, the body of the wood being perfectly sound and untouched; while the other, teak, is almost entirely eaten away.[1] An instance is also on record of a ship in the port of London having nearly the whole of the bottom planking eaten into by worms, with the exception of one plank, which proved to be of greenheart.[2] Mr. Stevenson published the result of exposing different kinds of timber to the attacks of the *Limnoria terebrans* at the Bell Rock in 1814, 1821, 1837, and 1843, and in the table of relative durability it is stated that greenheart was all but quite sound, being affected only in one corner, after having been exposed for a period of nineteen years. Greenheart is also said[3] to rank next to teak for resisting the white ant. This immunity is supposed to be owing to the fact that it possesses a large quantity of some powerful empyreumatic oil. Captain Fowke, in his report of experiments made by him on woods at the Paris Exhibition, 1856, mentions a black variety of greenheart from Masaruni river. This wood is used for the same purposes as the yellow greenheart, but it is considered even more durable. It is a handsome wood, and takes a high polish. It is distinguished from the common greenheart only by its colour; but it is so scarce, in proportion to the brown, or yellow type, that not more than one in twenty trees cut down are found to belong to this variety. It is in great request on account of its well-known durability, being preferred to all other woods for windmill shafts, spindles, and mill-work in general. The specific gravity is stated by Captain Fowke to be very slightly greater than that of the common variety of greenheart (1·089); the crushing weight of one cubic inch, treated as before, to be considerably more (15,432 lbs.); but the transverse strength less (13,224 lbs.).

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[1] Paris Exhibition Report, 1856. Specific gravity, 1·052 = about 65½ lbs. per cubic foot.

It is characteristic of greenheart timber to split open at the ends clean across the pith in seasoning,[4] there being frequently two such splits crossing each other nearly at right angles, and cleaving the log at the end into four quarters. These splits do not, however, usually extend more than two or three feet from the end, and the defect is to some extent compensated for by the fact that the logs do not split so as to form deep shakes along the sides in the course of seasoning, as do most other woods; hence there is not, after all, more than the ordinary amount of waste in the conversion of this kind of timber. Further, it is remarkable for its freedom from knots, and also for its general soundness, the only defect, beyond the splitting of the ends before mentioned, being a cross fracture of the longitudinal fibres—a defect which is only occasionally seen.

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[1] *Encyclopædia Britannica*, Art. "Greenheart."

[2] See *Report of the Colonial Botanist to the Cape Parliament*, 1866.

[3] Hurst's edition of *Tredgold's Carpentry*, 3d ed. 1880, p. 490.

[4] Laslett, *Timber and Timber Trees*, 1875, p. 152.

The greenheart timber is not usually hewn in the perfect manner that teak, mahogany, and many other woods are when prepared for shipment to the markets of this country, but comes from Demerara only partially dressed, a great deal of wane being left on along with the "snapped ends." It is forwarded in the condition in which it is prepared for drawing out of the forests. Its form should be considered with the price quoted per load, as it will not compare favourably in this respect with well-squared timber. Greenheart ranks Class 2 at Lloyd's.

(2) *Mora* (*Mora excelsa*) is also the produce of Demerara, as well as of Trinidad. It is one of the most majestic trees of the forests of Guiana, where it attains a height varying from 100 to 150 feet, and is frequently found 60 feet in height without a branch. When of that length it will square to a size varying from eighteen to twenty inches on the side, but it is then seldom sound throughout.[1] It is a tree, of straight growth, and generally yields timber in the log from eighteen to thirty-five feet in length and twelve to twenty inches square. The wood is of a chestnut-brown colour, hard, heavy, tough, strong, and generally straight in the grain, but has occasionally a twist or waviness in the fibre, which imparts to the logs possessing it a beautifully-figured appearance, and gives to them much additional value. It is also difficult to split, a property which renders it peculiarly adapted for shipbuilding. The trunk makes admirable keelsons, beams, engine-bearers, and the like, and the branches, having a natural crookedness of growth, are unsurpassed as knees. Were men-of-war ceiled with this

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[1] Hurst's *Tredgold's Carpentry*, 3d edit. 1880, p. 491.

wood little mischief would be occasioned by splinters during action.[1] In this important property Mora greatly excels teak. Star-shakes are frequent in the logs, and only the best trees can be advantageously converted into planks and boards, but it may be used with greater profit for the purposes mentioned above, and in a general way in large scantlings.[2] The Mora possesses great strength, and contains an oily or glutinous substance in its pores, which is probably conducive to its durability. Laslett gives its weight at 67·94 lbs. per cubic foot, but Captain Fowke at about 57 lbs. The latter authority states the crushing weight in the direction of the fibre to be 9920 lbs. for one cubic inch; the transverse strength of a specimen two inches square and twelve inches between the supports being 9697 lbs. on its middle. Laslett gives the comparative transverse strength, English oak being 1·000, as 1·644; and the comparative elasticity, English oak being 1·000, as 1·051. The Mora tree is believed to be very abundant along the rivers of the coast region; it grows luxuriantly on sand-reefs and on tracts of barren clay known as "Mora clay," a soil so sterile as not to admit of profitable culture. Sir R. Schomburgh,[3] referring to this tree, says that in Guiana gigantic trees grow on the land adjoining the Barima at its upper course. This river is navigable for vessels of twelve feet draught, and those intended for the transport of the timber might load at the very spot where the trees are cut down. In Captain Fowke's report upon the woods at the Paris Exhibition referred to before, it is stated that the price of Mora timber at that time was 1s. to 1s. 6d. per cubic foot in Guiana. Mora ranks Class 2 at Lloyd's.

(3) *African Oak* is sometimes called African teak or African mahogany, and partakes largely of the characteristics of the oak of Europe and America and of the teak of India. It is probably the *Swietenia Senegalensis* or *S. Khaza*, and is imported from Sierra Leone.[4]

The tree is of straight growth, and the height, as estimated from the logs imported, must be at least from 30 to 40 feet clear of the branches, with a circumference varying from 7 to 8 feet.

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[1] Captain Fowke, Paris Exhibition Report, 1856.

[2] Laslett, *Timber and Timber Trees*, 1875, p. 186.

[3] *Society of Arts Journal*, 1859, p. 431.

[4] Laslett, *Timber and Timber Trees*, 1875, p. 145.

The wood is of a dark red colour, very hard, strong, rigid, and difficult to work or cleave; it has a fine, close, straight grain, is of remarkable solidity, has no injurious heart-shake, and shakes of the cup or star kind are extremely rare in it; the centre wood, about the earlier concentric circles, is close and very compact, differing less from the outer layers in texture than in most other trees. In seasoning, this timber shrinks very little; it rarely warps, and stands exposure to the weather a long time without opening by surface shakes or sustaining any apparent damage.

The timber is brought upon the market in very roughly hewn logs, intended, perhaps, to be square, but varying considerably from that form, and taking, generally, the most irregular shapes. Sometimes they are angular, at other times they have a thick and a thin edge, resembling, in some degree, a "feather-edge" board; they are neither tapered to the natural growth of the tree, nor made parallel longitudinally, but vary in thickness in that direction, leading to a most serious waste of the raw material through the neglect to preserve the fullest-sized square log obtainable from the tree. It will naturally be inferred that, being thus awkwardly shaped, it is the most difficult of all timbers to measure correctly.

This African timber, possessing, as it does, so many good qualities, is employed in shipbuilding for beams, keelsons, riding-bitts, stanchions, and the like. The weight per cubic foot is given by Laslett as 62·06 lbs.; the comparative transverse strength, English oak being 1·000, as 1·374, and the comparative elasticity 0·923.

At Lloyd's this wood is classed with Greenheart, Mora, and others.

As to the source of supply little seems to be published of a reliable nature. It is, however, pretty certain that great forest tracts exist in the hilly country on the Sierra Leone coast—a region traversed by very numerous rivers, running almost parallel to each other, and at right angles to the coast, and stretching far inland through Senegambia and Liberia.

(4) *Jarrah* (*Eucalyptus marginata*) is found in Western

Australia, where it is said to be very abundant. It is of straight growth and very large dimensions, though, unfortunately, it is liable to early decay in the centre. The sound trees, however, yield solid and useful timber varying from twenty to forty feet in length, by eleven to twenty-four inches square, while those with faulty centres furnish only indifferent squares of smaller sizes, or pieces unequally sided, called flitches.[1]

The wood is red in colour, hard, heavy, close in texture, slightly wavy in the grain, and with occasionally enough figure to give it value for ornamental purposes; it works up quite smoothly, and takes a good polish. It is considered a first-class wood for shipbuilding,[2] but is somewhat slow to season, and if exposed before being seasoned is apt to "fly" and cast.

Jarrah timber is said to escape at least partially the ravages of the white ant, for although the sap or outer wood is sometimes pierced, the red timber, which constitutes the main body of the tree, may not be attacked.[3] The *Teredo navalis* is also said to avoid it.

Correspondence between the Home and Colonial Governments has been entered upon concerning Jarrah timber, as well as between the Governor of Western Australia and the leading shipbuilders and shipowners, including Lloyd's surveyor at Fremantle, who had been severally asked to report upon the merits of the Jarrah with a view to getting it recognised at Lloyd's.[4] Most of the shipbuilders and shipowners reported very favourably, and spoke of it as a good description of wood, but Lloyd's agent at Fremantle, while recognising its value for planking purposes as high as the wales, and for small craft which are not intended to be sheathed with metal, inasmuch as it resists the sea-worm better than almost any other wood, and is less liable to foul, did not consider it suitable for top-sides or deck-work, on account of its being in such positions very liable to shrink and warp, and of its deficiency in tenacity of fibre.

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[1] Mr. Reveby, an engineer to the Government, says of Jarrah: "There are forests of this wood (almost wholly) in West Australia of more than four miles in depth, which are known to extend for a length of 150 miles, covering an area of more than 364,000 acres, and containing timber sufficient to build 20,000 line-of-battle ships."—*Society of Arts Journal*, 1859, vol. vii. p. 433.

[2] Britton, *A Treatise on the Origin, Progress, Prevention, and Cure of Dry-rot in Timber*, 1875, p. 115.

[3] Hurst's *Tredgold's Carpentry*, 3d edit. 1880, p. 481.

[4] That body, a few years ago, had the subject under consideration, and determined to class this timber with those in line 3, Table A, of the Society's rules.

The clerk of works at Fremantle, reporting summarily upon the opinions expressed by the shipbuilders and others, says that the sound timber resists the attack of the *Teredo navalis* and "white ant." On analysis by Professor Abel it was found to contain a pungent acid that was destructive to life. The principle, however, was not found to be present in the unsound portions. Great care was always necessary in preparing the wood for use by flitching the log, so as to cut out all the defective portions of the heart, and use only the perfectly sound timber. Its density renders seasoning very slow, and the inner portions of the larger trees are in a state of decay even while the outer portions are in full vigour. A tree under these conditions, shipped at once to a hot climate like that of India, or to such a variable one as that of England, very naturally bursts from unequal shrinkage. The Jarrah should accordingly be felled when the sap is at the lowest ebb, and flitched as previously suggested.

Laslett gives the weight of Jarrah as 63·12 lbs., its comparative transverse strength, English oak being 1·000, as 0·850, and its comparative elasticity as 0·667.

(5) *The Tewart or Tooart Tree* (*Eucalyptus goniocephalus*) grows in tolerable abundance on the coast of Western Australia in its more southern parts, particularly in the limestone regions,[1] being found principally in the Swan River and King George's Sound district.[2] It is a tree of straight growth and great dimensions, yielding timber varying from twenty to forty-five feet in length by from eleven to twenty-eight inches square. It is recorded that planks are sometimes obtained ten feet wide.

The wood is of a yellowish or straw colour, hard, heavy, tough, strong, and rigid; the texture close, and the grain so twisted and curled as to render it difficult either to cleave or work. It is said to be peculiarly adapted for the building of ships of war, as it is most difficult to split, and is not liable to splinter. It is a very sound wood, possessing few or no defects, with the exception of a mild form of heart- and star-shake at the centre, which would necessitate a small amount of waste if it were required to reduce the logs into thin planks or boards; but if employed in large scantlings, it will be found a most valuable wood, especially where great strength is needed.

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[1] *Society of Arts Journal*, 1859, vol. vii. p. 342.

[2] Laslett, *Timber and Timber Trees*, 1875, p. 330.

The Tewart shrinks very little in seasoning, and does not split while undergoing that process. It is also characteristic of this wood that it will bear exposure to all the vicissitudes of weather for a long time without being in any but the least degree affected by it. Laslett states that he has known it to be subjected to this severe test for fully ten years, and, when afterwards converted, to open out with all the freshness of newly-felled timber. Possibly no better evidence is required to show that this is a durable wood.

It is used in shipbuilding for beams, keelsons, stern-posts, engine-bearers, and for other works below the line of flotation, for which great strength is required, a weighty material in that position not being objectionable in a ship's construction.[1]

The weight of Tewart is 73·06 lbs. per cubic foot. Its comparative transverse strength, English oak being 1·000, is 1·276, and its comparative elasticity 1·747.[1]

This wood does not appear to be recognised at Lloyd's unless it is entered in their "Table A" under quite a different name.[2] So long ago as 1859, Mr. Leonard Wray, in a paper read before the Society of Arts,[3] said that it would no doubt attain a high rank at Lloyd's, and would be very extensively employed in shipbuilding, provided it could be obtained in sufficient quantities.

(6) *Silverballi.*[4]—This tree grows to a great height and size, but is then often hollow. It will, however, square sound to sizes varying from ten to fourteen inches on the side, and from forty to fifty feet in length. It is a native of Guiana. The

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[1] Laslett, *Timber and Timber Trees*, 1875, p. 330.

[2] The various woods named in Lloyd's "Table A" might be designated more particularly for identification.

[3] *Society of Arts Journal*, 1859, vol. vii. p. 428.

[4] Captain Fowke, *Report on Woods at Paris Exhibition*, 1856.

wood is much lighter than water, and contains a bitter principle which resists the attacks of worms, hence it is much used in the Colony for the outside planking of vessels and boats. It is also used for masts and booms. There are four varieties or species of this tree, distinguished as Black, Brown, Yellow, and White Silverballi. Of these the last is least esteemed. The specific gravity is given by Captain Fowke as 0·546 (a little over 34 lbs. per cubic foot); the crushing weight in the direction of the fibre of a specimen one cubic inch as 7716 lbs.; the breaking weight applied transversely in the middle of a specimen two inches square, and twelve inches between the supports, as 4297 lbs.

The adoption of the preceding woods will depend chiefly upon the quantities that can be imported, their adaptability for shipbuilding purposes having been sufficiently attested.

The following timbers, chiefly from India, are, though as yet less known, also suitable for use below the line of flotation, or where special strength is necessary:—

(1) *Michælia champaca*, order *Magnoliaceæ;* vernacular names Champa, Sampagi-maram, etc.—This tree is indigenous to India generally. It is found wild[1] in Nepal, Bengal, Assam, Burmah, and in the forests of the Western Ghâts as far as Kanara, and it is cultivated throughout India from the Ravi southwards, and up to 5400 feet in the North-Western Himalaya. It is a tall evergreen tree, with grey bark half an inch thick. It is said often to reach eight feet in girth at an age of from 100 to 120 years; specimens show seven rings per inch of radius. A remarkably large specimen was exhibited at the Madras Exhibition in 1855 by Captain Cunningham, its dimensions being eleven and a half feet in length, four and a half feet in breadth, and three inches in thickness; it was apparently derived from a tree of very great age.[2] The wood varies from 37 to 42 lbs. per cubic foot in weight; it is soft, and seasons and polishes well. In appearance the sapwood is of a white colour, and the heartwood light olive brown; the annular rings are distinctly marked by a white line; the pores are small or of moderate size, and equally distributed; the

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[1] Gamble, *Manual of Indian Timbers*, 1883, p. 6.

[2] *Forests and Gardens of South India*, p. 236.

medullary rays are short, fine, or moderately broad, and are visible on a radial section. It is very durable—a specimen cut by Griffith in 1836, which was sent to the Paris Exhibition, and then to Calcutta—was found in 1881 to be as sound as if fresh cut. It is considered valuable in Northern Bengal for planking, door panels, and furniture; and in Assam for building canoes.[1] Its transverse strength is given by Gamble as P=560 to 642.[2] This is about the same as that of teak.

(2) *Lagerströmia reginæ*, order *Lythraceæ;* vernacular name, Jarúl.—This wood is found in Eastern Bengal,[3] Assam, Burmah, and along the western coast, extending north to Ratnagiri. It is the most valuable timber of Sylket, Cacher, and Chittagong, and in Burmah the most valuable after teak. The wood is shining, and light red in colour. Although light in weight (from about 37 to 47 lbs. per cubic foot) it is hard. The annular rings are marked by a belt of large pores; the medullary rays are extremely fine, and often indistinct. The Burmah wood is frequently very porous, with an abundance of large pores. The growth of the tree is moderate, averaging 4·6 rings per inch of radius.

It is used in shipbuilding, and for boats and canoes, all kinds of timber construction, and carts. The India Ordnance Department use it for many parts of their gun-carriages.

The value of P for transverse strength is 637 to 850.[3] This is very high for a light wood.

(3) *Dalbergia sissoo*, order *Leguminosæ;* vernacular name, Shisham; European name, the Sissoo.—It is indigenous to India. Gamble assigns this tree to the sub-Himalaya tract from the Indus to Assam, ascending to 3000 feet.

It is common as a good timber-producing tree along the banks of the Kuram, as well as its numerous tributaries, as far north as the village of Jelamai, at the base of Mount Kahutor, and is certainly indigenous to the country.[4] Brandis says that it will attain, under favourable circumstances, on an average, two and a half feet in girth in twelve years, and four and a half feet in girth in thirty years. In a number of trees cut during 1877 in the Changa-Manga plantations, from five to ten years of age, an average of 1·3 rings per inch of radius had formed. This calculation was based on the number of rings counted, but if the known age be taken the average will be 1·55 rings per inch of radius. These data refer to trees up to ten years of age only, and grown on irrigated land in favourable conditions. Specimens from the Jhelum Sarlaba plantations on non-irrigated land gave four rings per inch of average radius. This would make thirty years to a girth of four feet, which is nearly Brandis's estimate. In appearance the heartwood is brown, with darker longitudinal veins. It is close and even-grained, seasons well, and is very hard. The annular rings are not distinctly marked, there being alternating dark and light coloured bands which run into each other. The pores are large, or of moderate size, uniformly distributed, and joined by irregular, narrow, wavy, white concentric bands. The medullary rays are white, very fine, uniform, equidistant, and numerous.[1]

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[1] Gamble, *Manual of Indian Timbers*, 1883, p. 6.

[2] The formula for the constant "P" is given on page 326.

[3] Gamble, *Manual of Indian Timbers*, 1883, p. 202.

[4] From paper read before the Linnean Society, June 16th, 1881, by Surgeon-Major J. E. F. Aitchison, F.L.S.

The wood is very durable, seasons well, and does not warp or split. It is highly esteemed for all purposes where strength and elasticity are required, in strength being only inferior to Sal. "For framings of carriages and similar work it is unsurpassed, owing to its fine seasoning and standing qualities."[2] Gamble gives the weight as 44 to 56 lbs. per cubic foot, and the transverse strength as P=606 to 967.

(4) *Hopea odorata*—vernacular name, Thingan.—This is one of the finest trees in Burmah. It is found in the "eastern moist zone," scattered in the evergreen forests of British Burmah, and the Andaman Islands.[3]

It grows principally near mountain streams, and in the evergreen forests. In Pegu it is comparatively scarce, but it is plentiful in Tenasserim, and large specimens are common to the east of Tsit-toung.[4] It is an enormous evergreen tree of the Sal tribe, and yields a strong compact and excellent timber, considered superior to teak.[1] In colour it is yellow or yellowish brown, and hard, close, and even-grained. Its pores are moderate-sized and large, but less numerous than in Sal. Its medullary rays are short, moderately broad, and with a few intermediate fine rays, very prominent, and joined by numerous white transverse lines. The rays are visible on a radial section as long straight bands, giving the wood a beautifully mottled appearance.[2] It is said to be more durable than teak. Gamble remarks that the specimens brought by Dr. Wallich in 1828 from Tavoy, though fifty years old, were perfectly sound and good. Boats made of it are said to last twenty years. It is used for house-building, boats, and canoes, and for solid cart-wheels. It yields a yellow resin or "dammar." Its weight varies from 45 to 58 lbs. per cubic foot. Its transverse strength is P=706 to 839.

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[1] Gamble, *Manual of Indian Timbers*, 1883, p. 124.

[2] *Memorandum on the Timber of Bengal* (Calcutta, 1862), by Clifford.

[3] Gamble, *Manual of Indian Timbers*, 1883, p. 40.

[4] *British Burmah Gazetteer*, 1880, vol. i. p. 127.

(5) *Altingia excelsa*—vernacular name, Nan-ta-roop (or Nanta-yop).—This is a lofty deciduous tree, found in the evergreen tropical forests in the south of Tenasserim and Assam. It grows with a clear stem varying from 80 to 100 feet, and a total height of 150 or 180 feet, with a girth of 15 or 20 feet.[3]

The wood appears to be variable as to density. In appearance it is of a reddish-grey colour, with lighter streaks. The annular rings are marked by a narrow belt of firm wood without pores. The pores are small and uniformly distributed in lines between the medullary rays. The medullary rays are fine, equidistant, and prominent on a radial section.[4] The wood is described as oily, and of a somewhat balsamic odour. According to Kurz, it is also one of the most valuable timber trees in Java. The rate of growth is said to be moderate,—six rings per inch of radius. Gamble gives the weight as 46 lbs. per foot.

(6) *Pterocarpus Indiens*—vernacular name, Padouk.—This is a lofty tree, sometimes evergreen, found in Burmah and the Andaman Islands. Home's Valuation Surveys in the Andamans gave an average of seven mature trees per acre, which shows that a large quantity of the wood might be made

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[1] Leonard Wray, Paper on "Timber for Shipbuilding," read before the Society of Arts (*Society of Arts Journal*, vol. vii. p. 428).

[2] Gamble, *Manual of Indian Timbers*, 1883, p. 40.

[3] *British Burmah Gazetteer*, 1880, vol. i. p. 129.

[4] Gamble, *Manual of Indian Timbers*, 1883, p. 175.

available for export.[1] The amount of sapwood in this tree is small. The heartwood is dark red, close-grained, and moderately hard, with a slight aromatic scent. The pores are scanty, small or large, and sometimes oval and subdivided. It has very fine white wavy interrupted concentric lines, irregularly distributed. The medullary rays are extremely fine, very numerous, uniform, and equidistant. The wood is used for furniture, carts, gun-carriages, and other purposes. It is said to be the most useful wood in the Andamans, where it grows to an enormous size.

Major Protheroe describes a tree felled in 1876 with a clean stem of sixty-five feet, and a girth of seventeen feet, and says that the wood of the root is close-grained, darker-coloured, and more beautifully marked than that of the stem. The plank sent to the Paris Exhibition of 1878 measured nearly four feet across. In London a portion of the same log from which the plank was cut fetched a price of £17, 10s. per ton.

Furniture made from Padouk wood, and exhibited at Paris in 1878, was much admired. The exhibitors, Messrs. Jackson and Graham, reported that the wood was straight, with rather a coarse open grain, but without any strong figure or markings; that when first cut up it was of a reddish-brown colour, but that it faded to much the same colour as teak. It seasons well, works well, and takes a very fine polish. It yields a kind of gum called "Kino." Gamble says that the wood from the Andamans appears from the specimens to be much lighter in weight, softer, and of a lighter colour than the Burmah wood.

EXPERIMENTS.

Tested by			Weight.	Value of "P."
Skinner,	1862,	Burmah Wood,	56 lbs. per foot,	864
Bennett,	1872,	Andaman ,,	49·5 ,,	827
Smythies,	1878,	,, ,,	48 ,,	...

(7) *Andira inermis* (*Angelique*), the produce of Guiana, is a tree of straight growth, yielding timber from twenty to fifty-four feet in length, and twelve to twenty-two inches square. This wood, with others, was selected from French Guiana timbers, under a commission appointed by the Colonial Government of St. Laurent du Maroni. The selected woods were imported

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[1] Gamble, *Manual of Indian Timbers*, 1883, p. 131.

into Havre in 1874. It is a species of teak, and it is believed to possess some of the more valuable characteristics of that wood; for instance, as to the non-corrosion of iron when in contact: "It is reported to have been used for some time in the French Dockyards as backing to armour-plates on ships, and as it does not appear to contain any acid, it might be employed in lieu of teak for a similar purpose in the Royal Dockyards in England."[1]

The wood is of a reddish-brown colour, clean and even in the grain, moderately hard, tough, strong, elastic, and not difficult to work, although it does not cleave readily. There is little sapwood. The timber is very round, and free from knots, and except that a small percentage of the logs have a slight heart-shake, or perhaps star-shake at the pith or centre, there are no defects affecting the conversion of it into planks, boards, etc., as may be required. It has been said that it does not rot in water, that it is proof against attacks from many insects to which other timber is liable, and that it is durable. It opens very round, and is tough, strong, and elastic. There is very little waste in the conversion. In working, however, some of the logs emit an unpleasant odour; and, unless in seasoning this should pass off by evaporation, it may possibly prove detrimental to its value for general purposes, as for the inside of ships, or in close, damp places. The weight of this wood is from 48 to 57 lbs. per cubic foot.

(8) *Fagræa fragrans*—vernacular name, Anan—is an evergreen tree. It is one of the most important of the reserved trees of Burmah, especially in Tavoy.[2] It is said to grow in the Eng and Hill forests, principally in Tenasserim, particularly up the river Attaran. It is also very abundant in other parts of Amherst and Mergui. The trees, which are of very slow growth, are from twenty-five to thirty feet in height, with a clear stem of ten or twelve feet only, and with an average girth of three or four feet.[3] The wood is yellow or light brown, white streaked and beautifully mottled; and it is compact and hard. There are pores of two classes—a large kind, scanty and often subdivided; and a small kind in narrow, wavy, concentric bands,

[1] Laslett, *Timber and Timber Trees*, 1875, p. 159.
[2] Gamble, *Manual of Indian Timbers*, 1883, p. 267.
[3] *British Burmah Gazetteer*, 1880, vol. i. p. 130.

which alternate with broader bands of firm and dark-coloured tissue, in which the numerous fine medullary rays are distinctly visible. The large pores (vessels of intercellular ducts) are prominent on a vertical section.[1] Its chief value as a timber is its durability when exposed to damp or water. It is not liable to the attacks of *Teredo* or of ants. The posts of a wharf at Tavoy, which were exposed for several years daily to the ebbing and flowing tides, being thus partly wet and partly dry, were untouched by worms.[2] Gamble gives the weight at from 53 to 65 lbs. per cubic foot, and the transverse strength, P=553 (the latter being Baker's experiments with Tavoy wood).

(9) *Peroba-Branca*, or *P. de campos* tree, is found in the forests of the Brazilian Empire. A specimen of small size was sent, with others, to the Admiralty in 1858, by H.B.M.'s Consul at Rio de Janeiro. Laslett reports upon it as follows:[3]—"The wood is yellow in colour, of moderate weight, close and fine in the grain, and not difficult to work. It takes a high polish. It attains large dimensions, and is fit for employment in architecture, for furniture, and generally in the domestic arts." A sample of this wood, 10 feet × 18″ × 6″, measuring seven and a half cubic feet, was sent to the Admiralty in 1875, with this description:—"Produced in square logs of about twenty-four inches on the side, and sixty to seventy feet in length. Sound timber of thirty to forty inches square is common. The tree is of straight growth, is stronger than teak, agrees well with iron, and is very durable. The specific gravity is 0·868 (about 53 lbs. per cubic foot). Brazilian ironclads are built with it."

(10) *Xylia dolabriformis*—vernacular names, Pynkado, Pyengadu, etc., and called by Europeans the Ironwood Tree—is said to be a species of acacia,[4] found in the Burmese forests. Dr. Schlich[5] says that one-third of the forest vegetation in Arracan consists of it; and Major Seaton[6] reported that 10,000 sleepers from Arracan had lately been sold in Calcutta at Rs.5 each.

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[1] Gamble, *Manual of Indian Timbers*, 1883, p. 267.

[2] *The Timber Trees of India, and E. and S. Asia*, by E. Balfour, Madras, 1862, p. 115.

[3] *Timber and Timber Trees*, 1875, p. 183.

[4] *Ibid.*, p. 129.

[5] Forest Report, dated 1st September 1869.

[6] Forest Report, 1876-77.

Laslett remarks that it is also found in the country occupied by the Karens, towards Western China, where it is often seen rising to seventy or eighty feet clear of branches, and of very large circumference. It yields timber in the log twelve to twenty-four and even thirty inches square, and of great lengths. Dr. Hooker says that it is found in India in widely distant parts. Throughout Tenasserim and the Malay peninsula it is called Peengado. It is abundant in the Bombay Presidency, where it is called Jambea and Yerool; in the Godavery forests it bears the name of Boja; it is common at Singapore, and it is also plentiful in the Philippine Islands. The wood is hard and durable, and the white ant will not touch it. It shrinks in seasoning one-eighth of an inch per foot of surface, and the density is 5 lbs. 10 oz. per superficial foot. It is one of seven or eight species of trees which Dr. Falconer, in his report of the teak forests of Tenasserim, earnestly requests the Indian Government to preserve.

The wood is of a reddish-brown colour, heavy, tough, strong, rigid, and frequently possesses some "figure" in the grain. Its pores are filled with a remarkable thick, glutinous, oily substance, which oozes out upon the surface after the wood has been worked, leaving a clamminess which cannot be completely got rid of until the piece is thoroughly seasoned. This oily substance has probably some preservative property, and may be conducive to the durability of the timber.[1] Some logs sent to Woolwich Dockyard in 1865 had extensive heart-shake. The weight appears to be from 59 to 66 lbs. per cubic foot, and the transverse strength $P=955$.[2]

(11) *Heretiera littoralis*—vernacular names, Sunder, Sundi, etc.—is a small gregarious evergreen tree. It grows in Burmah, the Peninsula, the coast and tidal forests of Bengal, and the Andaman Islands. It is the chief timber of the Sundarbans forests. Its reproduction is most favourable. The sapwood is white, the heartwood dark red, very hard, and close grained. The pores are of moderate size, or large, often oval and subdivided into compartments. The medullary rays are uniform, moderately broad, short, and wavy. Sunder wood is durable,

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[1] Laslett, *Timber and Timber Trees*, 1875, p. 129.

[2] Gamble, *Manual of Indian Timbers*, 1883, p. 149.

heavy, and does not float; it is extremely tough. It is used for a great variety of purposes, such as beams, buggy shafts, planking, posts, and the like, but chiefly in boat-building, for which purpose it is very extensively used in Calcutta, and particularly in the Government Dockyard at Kidderpore.

The weight of seasoned wood and the value of P have been determined by experiments, which show that the former may be taken at 65 lbs. per cubic foot, and the latter at 850.

(12) *Swietenia febrifuga* is a large deciduous tree. Sometimes the timber is called "Indian Redwood." Gamble mentions Central India and Dekkan as the districts in which it grows. The sapwood is small and whitish; the heartwood extremely hard and close-grained, reddish-black in colour, and said to be very durable. It is stated that the natives of India consider it the most lasting timber their country produces, and therefore use it upon every occasion where they wish to combine strength with durability. As to structure, Gamble says that the pores are of moderate size and scanty, the medullary rays being moderately broad and distinctly visible on a radial section as dark shining horizontal plates. Numerous fine concentric lines of lighter colour, often closely packed and forming broader bands, are seen. The wood is durable. Skinner remarks that a piece taken out of the workshop at Fort St. George, which had been erected in 1803 and pulled down in 1859, stood 1232 lbs. without breaking; for the experiment a scantling 3×1½‘×1½″ was employed. It is not much attacked by ants. Its weight, according to Skinner and Fowke, is 66 lbs.; according to Gamble it is 73·5 lbs. per cubic foot. The value of P, according to the former, is 1024; according to the latter it is 626.

(13) *The Chow*, or *Menkabang Penang* tree (probably *Casuarina equisetifolia*, nat. ord. *Casuarinaceæ*), is found in the island of Borneo, where it is said to be very abundant.[1] It attains large dimensions, is of straight growth, and yields timber in the log of from thirty to seventy feet in length, and from fifteen to twenty-six inches square. The earliest importation of the Chow timber into this country was about 1860-61, when it came direct to the London market, and thence passed into Woolwich Dockyard, to be experimentally employed for beams, keelsons,

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[1] Laslett, *Timber and Timber Trees*, 1875, p. 134.

and other purposes where strong, straight timber is required in shipbuilding; it gave every satisfaction.

The wood is of a yellowish or straw colour, close and fine in texture, straight in the grain, hard, heavy, tough, and exceedingly strong. It is used in Borneo and the countries bordering on the China Seas, for the masts of junks and other vessels, for house- and ship-building, and for a variety of minor purposes. Laslett gives the weight of Chow at 69·75 lbs. per cubic foot, the comparative transverse strength, English oak being =1·000, as 1·208, and the comparative elasticity 2·280.

It now remains briefly to refer, in a general way, to a few districts which are well adapted for extended exploration.

(1) *The forests of the Brazilian Empire.*—Southward from Central America there are to be found in the forests great varieties of timber trees, many of which are no doubt of good quality and fit for constructive purposes, but little or nothing is known of them in this country.[1]

The woods of the Amazon Basin have an almost priceless value. "Nowhere in the world," says Agassiz, "is there finer timber, either for solid construction or for works of ornament; and yet it is scarcely used even for the local buildings, and makes no part whatever of the exports. It is strange that the development of this branch of industry should not even have begun."[2] In Laslett's *Timber and Timber Trees*, p. 181, a description of twenty-four woods from these parts is given. The specimens were sent to the Admiralty in 1858, with the view of introducing some of them for employment in shipbuilding. No trade of consequence, however, seems to have yet begun in these timbers.

(2) *British Guiana.*—It is believed that, besides the Greenheart, Mora, and a few already-known woods, many others exist in abundance in the great forests of this district. Mr. Holmes, the Commissioner for British Guiana, in supplying the prices and descriptions of the various specimens of wood from that Colony for the Paris Exhibition of 1856, says:[3]—"The Colony

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[1] Laslett, *Timber and Timber Trees*, 1875, p. 181.
[2] *A Journey in Brazil*, by Agassiz, 1869, p. 509.
[3] Paris Exhibition Report, 1856.

is intersected by numerous large rivers, navigable for vessels of large burden, which can thus penetrate into the heart of primitive forests capable of affording an unlimited supply of timber; and as in many parts of the Colony the trees are cut down in the immediate vicinity of these rivers and creeks, the cost of the wood, which has been given wherever it could be ascertained, depends alone on the price of labour for felling and squaring."

It is surely time that some proper survey was made of these forests by Government authority, and, if such valuable woods abound, the areas should be demarcated, and a Forest Department organised to preserve and work their valuable products.[1]

(3) *Malacca* and (4) *Honduras* may be noted in few words. The former country (under which head may be comprised Penang, Malacca, and Singapore) is said to abound in timber woods almost unknown in Europe. Mr. Leonard Wray[2] describes a number of these woods, amongst which are the following:—

Murbouw, a very strong, hard, and heavy wood, used in shipping, which will last 100 years, and is not attacked by insects.

Bintangoor, a valuable wood for shipbuilding, especially for planks, masts, and spars, and the like. It grows in great abundance, especially near Singapore, and is largely exported to Mauritius, California, and other parts.

Giham, a pale yellow wood, close-grained, hard, elastic, very durable, and generally used in boat-building.

Marantee, a very large, light, resinous wood, much used for planking and for building boats.

As the Malays are first-rate woodmen and boatmen, and Chinamen are most industrious labourers, this locality may be considered as affording a promise of a large supply of timber.[2]

As to Honduras, it is thought that there is allowed to stand and waste a great amount of valuable timber which the woodmen ought to bring out of the forest, along with the mahogany, which is almost, with logwood, the only forest product which is made use of. It is said that the forests in which these lumberers live and work contain some of the finest quality timber in the world,[1] and that, in extraordinary profusion—the greenheart, the live oak (*Bignonia*), and other oaks, the mahoe, the bullet-tree, the Neesbury bullet-tree, the ironwood, the locust tree, the dogwood, and the cedar (*Cedrela odorata*,—a light and durable wood, not liable to dry-rot nor subject to the attacks of insects, the trunk of which is 70 to 80 feet long).

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[1] See also *Among the Indians of Guiana*, by E. F. Thurm, 1883, pp. 2, 88, etc.

[2] *Society of Arts Journal*, 1859, vol. vii. p. 428, on "Timber for Shipbuilding."

The imports for 1882 show that while mahogany has been brought from Honduras during the year to Britain to the extent of 10,173 tons, amounting in value to £92,331, *all other* unenumerated hardwoods were imported only to the extent of 1193 tons, of the total value of £9655.

In conclusion, the necessity of not merely maintaining, but of greatly increasing, and that permanently, our growth, care, and supply of Indian teak, is strongly to be urged. The science of Forestry has abundantly proved itself worthy of the patronage of the Governments of all nations. The establishing of "Schools of Forestry"[2] has turned out in France, in India, and elsewhere, qualified men to take the place of our veteran pioneers, who have so ably begun this *internationally important* work; and the interest in our day shown in the subject may well encourage us to believe that our maritime wants as to first-class shipbuilding timber will not only be supplied in the future, but supplied in greater abundance and of a better quality than at the present time.

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[1] *Society of Arts Journal*, 1859, vol. vii. p. 428, "On Timber for Shipbuilding."

[2] See Colonel G. F. Pearson's interesting paper on "The Teaching of Forestry" read before the Society of Arts, March 1st, 1882 (*Society of Arts Journal*, vol. xxx. p. 422).

XIII.

ON THE BEST METHOD OF MAINTAINING THE SUPPLY OF TEAK, WITH REMARKS ON ITS PRICE, SIZE, AND QUALITY, AND ON THE BEST SUBSTITUTES FOR SHIPBUILDING PURPOSES.

By John C. Kemp, *Glasgow.*

When teak wood was first introduced as a shipbuilding material, our supplies were almost entirely drawn from the immense forests of India proper, but as these have, from various causes, become greatly diminished, our chief sources, for many years past, have been the forests of Burmah, and more recently those of Siam. As Burmah teak, however, has many distinctive features which render it vastly superior to that found in other localities, it is a matter of great importance to maintain in that territory a supply of first-class trees, sufficiently large to meet the very great demand that exists for them in this country.

Hence the following remarks will specially apply to wood grown in Burmah, and in dealing with the subject we shall consider—

I. The supplies of teak with reference to that available for shipbuilding purposes; the growth of the tree, and the quantity imported into and consumed in the United Kingdom and on the Continent during recent years.

II. The average size of past supplies, with suggestions how to maintain that of future shipments.

III. The quality.

IV. The price.

V. The best substitutes for shipbuilding purposes.

I. THE SUPPLIES OF TEAK WITH REFERENCE TO THAT AVAILABLE FOR SHIPBUILDING PURPOSES; THE GROWTH OF THE TREE, AND THE QUANTITY IMPORTED INTO AND CONSUMED IN THE UNITED KINGDOM AND ON THE CONTINENT DURING RECENT YEARS.

That an outcry regarding a falling off in the supply of Burmah teak has been raised of late is well known, but, as in the case of Canadian white pine—which according to figures published many years ago was to have ceased ere this—such fears have had little foundation in fact. Such a calamity has no doubt been averted in the forests of British Burmah by the action of the Forest Department, which has made such satisfactory progress in its work of administration there, that it may reasonably be hoped that very soon the entire extent of these forests will be under its control. This will have the effect of protecting undue waste in felling, and of providing for a renewal of the trees as soon as the soil is ready to receive them. But the case of forests situated beyond the boundary of British Burmah—and these afford a considerable portion of our present supplies—is different; and yet it is satisfactory to know that the beneficial effects of the measures adopted by the Forest Department of that territory are being recognised throughout the country, and that greater attention is everywhere being paid to provide for a renewal of the trees as soon as the tracts are cleared. It is unfortunate that it is impossible to give figures to show the number of square miles which are at present covered with teak not yet touched, or only partially so, as well as impracticable to define the tracts that are covered with young trees and those that carry wood bordering on maturity. This is due to the fact that teak is not found in tracts growing alone, but is one of the many trees that make up what are called "mixed forests,"—*i.e.* forests that contain many other trees that are associated with teak, and without which the latter does not attain the same value either in point of size or quality.

Exporters and others, however, who are in a position to speak with authority, are agreed that no apprehension of a falling of in the supplies from any ordinary cause, such as an increased demand, need be entertained; and as it is to the advantage, pecuniarily and otherwise, of the Government of India and the proprietors of the different forests to maintain teak in sufficient quantity to meet all demands for it, their aim has of late been to do so to the greatest extent possible.

As to the quality of the timber suitable for modern shipbuilding purposes, it is to be borne in mind that as this has to be of the highest standard, great care is taken by the merchants at the shipping ports to secure this standard for the European markets. In proof of this it may be noted that only a small number of imported logs turn out to be hollow inside—a defect caused by a wasting away of the early annual layers of wood before the tree reaches maturity,[1] yet the proportion of young trees so affected that are brought from the forests to the shipping ports is very considerable. Such logs, however, find a ready market in India, where teak is in great demand, being used for almost every conceivable purpose in which timber can be employed, and yet it is not obtainable from the home forests in any quantity. Thus during the years 1880-81 and 1881-82, 85,548 and 81,750 loads, consisting for the most part of wood unsuitable for shipbuilding purposes, were imported into that country. In India, as in Burmah, the work of the Forest Department has progressed so rapidly of late years, that soon, it is hoped, a larger proportion of the teak required there will be home-grown, but that it will never again be allowed to attain its full growth in any quantity, as it does in Burmah, is a foregone conclusion. Yet the forests of the Central Provinces, Bombay, Mysore, etc., produce poles of considerable length, which are valuable as a building material, and this will to some extent relieve the demand for Burmah timber for the frontier trade—a result which is being more speedily achieved by the bringing into prominence of some of the countless trees which abound in India and Burmah, and which have been proved to be capable of very many useful applications. The growth of these substitutes, moreover, is now encouraged by the Forest Department wherever they can be profitably allowed to remain, but formerly nothing was done for their conservancy, as no one demanded anything but teak in the market.

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[1] This is probably the effect of forest fires on the young saplings, which may be burnt down several times before they finally succeed in establishing themselves.

The *growth* of teak varies enormously, and it is not possible to say how long must elapse before a tract which has been cleared will be again covered with timber ready for the axe. In some parts, for example, the trees do not come to maturity until about their eightieth year, while in others they have assumed very large dimensions in half that period. Hence it becomes very difficult, if not impracticable, to procure reliable figures to show how long the present rate of exportation may continue without impairing the supply.

In those forests now under the administration of the Forest Department in British Burmah, which at present cover about 4000 square miles, different systems are followed to maintain the standard of their productiveness, and it may be interesting to quote the following, which has proved both inexpensive and highly successful. Plots of land, which produce only "inferior species," are given out to the hillmen, who cut down the existing vegetation, burn it, and then with their crops raise teak trees, which are planted in lines six feet apart each way. After the harvesting of these crops, the men engage, for a reward, to keep the saplings clear for two or even three seasons, until they are able to take care of themselves, whereupon the tract is handed over to the Government officer. The value of such a plan, in places where labour is scarcely to be had, is inestimable, and on the whole it seems probable that the maintenance of the forests of Burmah is thereby placed on a satisfactory foundation.

If the unexpected were to happen, and a future generation were to find itself unable to obtain teak in the desired quantity from this source, there would still be the forests of Siam to fall back upon, cargoes from which have already been shipped at Bangkok. Mention has also been made by some of Java teak; but its present manufacture, quality, and size, render it useless as a shipbuilding material. It is extremely short and stunted, and in all respects inferior to either of the preceding, while, in point of value, it is scarcely worth a third of the Burmah wood.

That Bangkok teak will ever come into prominence as a ship-building material is doubted,[1] as the existence of most injurious heart- and star-shakes reduce the number of logs that are fit for conversion into planks or boards to 25 or 30 per cent. of the total number exported. The remainder are only capable of employment in bulk, or when reduced to scantlings—a process which involves heavy loss. The Bangkok teak, besides being more brittle, is less abundantly supplied with the essential oil which distinguishes Burmah timber, and is therefore deficient in the rust-resisting qualities that contribute so greatly to the value of the latter. Moreover, the logs are not unfrequently too much dotted with bee-holes to attract the attention of any one wanting first-class wood. Its value, when we take into account the relative smallness of its size and other defects, cannot be said to be within 30s. a load, at the least, of that of Rangoon timber.

In 1882 upwards of 1500 loads of Bangkok teak were imported into this country, and in 1883 this amount rose to upwards of 3000 loads. This great increase was owing to the fact that the forests, or a large portion of them, along with the saw-mill plant, were leased by one firm, who sought to introduce this timber to the home markets, but about three years ago, one or two cargoes which were sent to the Clyde were found unsuitable for consumption there, on account of the price and the defects above referred to, and no further importation has taken place. With reference to the export of teak, the following figures, selected from returns made to Parliament, refer to shipments from Burmah to all ports other than those of India. They therefore depend mainly on the demands of Great Britain and the Continent, and are given for the twelve months from April 1 to March 31 of each year:—

In the year 1874-75, there were exported 42,868 loads; in 1875-76, 60,612 loads; in 1876-77, 45,108 loads; in 1877-78, 56,939 loads; in 1878-79, 37,413 loads; in 1879-80, 38,620 loads; and in 1880-81, 65,626 loads. This gives an average for those years of 49,598 loads, of which possibly from 3000 to 5000 loads found their way to other ports than those of the United Kingdom and Continent. The great increase in 1880-81 may be attributed to the greater demand existing in Great Britain and on the Continent for this timber for shipbuilding purposes.

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[1] Probably this is due to want of care in selecting the timber for exportation. There is no reason to suppose, as far as is known at present, that teak of first quality is not obtainable in Siam.

Of this great quantity of exported timber the Clyde lays claim to being the largest annual consumer. Here the consignments for the years 1876 to 1883 amounted to 95,329 loads, which were distributed as follows:—in 1876, 8890 loads; in 1877, 14,890 loads; in 1878, 6517 loads; in 1879, 5133 loads; in 1880, 16,285 loads; in 1881, 12,826 loads; in 1882, 13,794 loads, and in 1883, 16,994 loads. This gives an average import of 11,916 loads per annum, which is almost equal to 24 per cent. of the total annual export from Burmah.

The Thames ranks next the Clyde as a consumer of teak, the average import for the past four years from Burmah amounting to 8340 loads, or very nearly 16¾ per cent. of the total export. To this must be added an average annual import from Bangkok of about 850 loads.

With respect to some of the other ports in the United Kingdom, the following statistics for the year 1882 may be taken as a guide for prior and subsequent years:—The Mersey received 3500 loads; the Tyne, 4970 loads; the Wear, 3600 loads; the Government dockyards, 4550 loads, and other ports about 2050 loads. It thus appears that the total consignments to the United Kingdom for that year amounted to upwards of 40,650 loads, while upwards of 6000 loads were sent to the Continent.

That the above quantities were not more than the amounts actually required may be shown by the following figures, which represent the consumption at the same ports during the years to which the above statistics refer:—

The Clyde, during the year 1876, consumed 8850 loads; during 1877, 10,348 loads; during 1878, 8604 loads; during 1879, 10,364 loads; during 1880, 10,796 loads; during 1881, 14,364 loads; during 1882, 17,571 loads; and during 1883, 16,598 loads. This represents an average annual consumption of 12,187 loads, an amount which exceeds the average annual imports by 270 loads, the deficit being accounted for by the stock carried over from the year 1875. Similarly the Thames shows an annual consumption of 9000 loads, the excess over the imports being explained in the same way.

During 1882 the Mersey consumed 3400 loads; the Tyne, 3867 loads; the Wear, 3356 loads; the Government dockyards, 3030 loads; and the other ports, 2050 loads; while on the Continent upwards of 6000 loads were used.

In giving these figures no account has been taken of the quantity annually re-shipped from this country to the Continent, as it forms an extremely small percentage of the totals. But while it is to be noted that the average annual consignments to the United Kingdom, amounting to upwards of 42,000 loads, has not been more than sufficient of late years to meet the demand, it is also to be borne in mind that there exists an intimate relationship between the condition of the shipbuilding industry and the quantity of teak imported—a lull or activity in the former causing a diminution or increase in the latter.

II. THE AVERAGE SIZE OF PAST SUPPLIES, WITH SUGGESTIONS HOW TO MAINTAIN THAT OF FUTURE SHIPMENTS.

In considering this point one cannot fail to notice the decrease in the average length and cubical contents of the teak shipped recently, as compared with what was exported a dozen years ago. This is made manifest by the fact that the Admiralty standard for their teak contracts, which was formerly 28 lineal feet, the minimum length being 24 feet, is at present 26 lineal feet, the minimum being 23. This reduction was made on account of the great difficulty experienced in getting cargoes which would satisfy Government requirements, and recently shipments averaging less than 27 lineal feet have become more common, although the minimum of what is termed "long timber," in contradistinction to "short girthy timber" or "shorts," is still maintained. Thus three well-manufactured cargoes of excellent quality recently imported averaged 26·03, 26·28, and 26·41 lineal feet per log respectively, the exporters apparently considering good butting and topping sufficient to compensate for the somewhat shorter length. Where extreme length is wanted it is apt to be obtained at the expense of bad butting, but such a defect is a serious one, because the value of the timber, in the estimation of the buyers, tends thereby to be lowered to too great an extent.

As far as growth is concerned, timber of very large dimensions can be obtained ; but the condition of the ground over which it has to be dragged, and the nature of the streams by which it has to be floated, limit the lengths which can be brought to the market. Thus teak, when growing in a soil and climate well adapted for it, assumes magnificent proportions, specimens varying from ten to fifteen feet in circumference being by no means rare, and the stem often rises to a height of 70 or 80 feet without a branch; yet the difficulty of bringing very long logs from the forests to the shipping ports involves a great increase of labour and expense.

It must also be borne in mind that while it is the desire of the merchant to maintain, if not to increase, the lengths of exported timber, he can only carry this out to such an extent as is consistent with no undue waste in the process of manufacture. To do so it is his aim to provide from a given log two pieces as long as possible,—the one being, it may be, from 15 to 23 feet in length, and from 18 to 24 inches on the side, and the other 23 feet or upwards, and from 15 to 20 inches on the side. Yet it should not be difficult to produce greater lengths than are usually found in cargoes, if only a little more care were taken to prevent waste in the forests, and this might be accomplished by cutting off the bole, not below the branches, as is ordinarily done, but so as to include the knots of some of the lower ones.

There is one point which must appear strange to the consumer, in regard to the short girthy timber, namely, the fact that in manufacturing the tree, the merchant does not first of all take off a long log varying from 23 to 30 feet in length, giving it at the same time greater girth, at the expense of the short log. It is of course evident that the latter in that case would not obtain the price which short girthy timber at present commands, but then the former would be more valuable, although the consumer might have grave objections to have its price increased, on the ground that it is dear enough already.

If the merchant objects to this, it then follows that, having mulcted the long timber, which the consumer wants, of its size and quality, to give it to the short, which he does not want, in fairness to the buyer a greater reduction should be made than is at present done in the price of the latter. That it would benefit the consumer to let the long log be at the same time the girthy one, even at the expense of an addition to the price of it, cannot be doubted.

It must however be noted that when there is timber in the market of different averages, the buyer generally prefers the smaller, on account of its being a little cheaper, unless the quality of the wood is decidedly objectionable, and merchants are thus encouraged to ship the smaller sizes, as these pay them best. If, on the other hand, consumers invariably gave the preference to the larger timber, the quality being of course presumed to be equally good, then logs of larger dimensions would alone be exported; but as it is, the merchant cannot be blamed for providing, when it costs him less to do so, what he finds the consumer very willing to take.

III. THE QUALITY.

On the principle that bad timber cannot be cheap at however low a price it is obtained, teak of the first quality is what must be demanded by all who use it. Whether this quality has deteriorated to any appreciable extent during the last ten or a dozen years—which is quite a sufficient length of time for us to go back, when we consider that the parcels shipped then satisfied the expectations or demands of the consumers—cannot but remain a doubtful question. It is true that some (for there are numerous exceptions) builders and others who have been unfortunate enough to receive into their yards a portion of an inferior cargo, believe that such a deterioration is yearly in progress; and it must be admitted that there are in every year's shipments some parcels which show a falling off in this respect. Yet if the opinion of the importer, who has the opportunity of inspecting many cargoes annually in their entirety, is to be accepted, the average quality, taking one year with another, seems to be fully maintained. That one shipment may differ from another in many respects is, in the nature of the case, to be anticipated, when it is borne in mind that the forest ranges of Burmah extend over several thousands of miles, presenting many varieties of soil, altitude, and exposure. These all exercise an important influence on the character of the timber produced, and so, too, do the particular species of trees which are associated with teak in the formation of the mixed forests, and which are essential for sapling teak on account of the shade they afford, as well as from the fact that they prevent the washing away of the soil by heavy rains.

It is a characteristic of teak timber to have the heart-shake more or less well defined, and wood from some of the forests invariably possesses a close fine star-shake radiating from the pith. It is considered by some that the practice of girdling is injurious, in causing or extending the heart-shake. This process consists in cutting through and removing a complete ring of bark and sapwood in order to kill the tree. The operation is performed three years prior to felling, and it speedily accomplishes its object, as the tree dies in a few days, or weeks at most. Experiments have shown, however, that it exercises no influence on heart-shakes, inasmuch as this occurs in about one-third of those trees that are cut down in the living condition, yet it may be considered objectionable on the ground that the timber dries too rapidly, is liable to become brittle and inelastic, and to break in falling. It must also be regarded, and this is of great importance, as taking so much time from the limit of the duration of the trees. As its chief, if not only, advantage is that the wood can be floated immediately after being felled, it has been given up where circumstances permitted it.

In logs procured from old trees the heart-shake is found to extend to one-half and sometimes to two-thirds of the diameter, and to stretch along their entire length. If this shake is in one plane throughout, the conversion of the log involves no greater difficulty or loss than that occasioned by dropping out a piece large enough to include it. When, however, as in other instances, the cleft or shake at the top is at right angles, or nearly so, to that at the butt-end, it is rather more serious, as the log may have either to be used in bulk, or worked up for small scantlings, such as could be obtained if it were cut up into two or more lengths. If the shake extends only a few feet from the butt-end the most profitable way of converting the log is to cut it into planks or boards, care being taken to work it from the outside, and thus waste only a tapering or wedge-like piece sufficient to include the defect.

While it is impossible to escape the heart- or star-shake, there are other faults of which the consumer complains, and without which it is difficult, if not impossible, to procure cargoes. These are bee- and worm-holes, which as a rule affect only a very small percentage of a cargo : rotten knots,—in some parcels too prevalent, bad butting, and a wane in the manufacture of the logs. Such defects could only be avoided by rejecting at the shipping ports logs so affected, but as this would tend to raise the price too much, it is not to be recommended.

The presence of a wane cannot be said to be a serious drawback, although it is by some loudly complained of, the chief reason for the complaint being found in the fact that as teak is sold by "Queen's Customs Calliper Measure," and not by "String Measure," as is the case with waney board-wood, the consumer has to pay for, it may be, from 10 to 15 per cent. of timber more than he actually receives. This wane, moreover, is in many cases unavoidable, as the squaring of some of the logs would involve a serious waste of thoroughly sound timber, and leave too great a proportion of heart-wood, thus causing a very great loss in the conversion of the piece.

Another common complaint is that the "claws," used in dragging the log to the streams, are such as to make holes about one inch and a half long by three-quarters of an inch broad, in two of the sides of the piece. As these claws require to be placed, in order to satisfy the whim of the elephants, near the middle of the log, they cause much waste in the conversion of the outside plank. This, however, might easily be avoided by the use of claws of the pattern generally adopted in this country, which consist of two hooks with a chain passed through a ring, secured in each of them in such a way as to fasten the hooks when a strain is applied to the chain. (See Fig. 6.)

To improve the quality of future shipments, exporters should endeavour to avoid the faults above mentioned. The damage done by the deep "claws" is unnecessary, and should not be seen in future, and there would doubtless be fewer complaints from buyers if, in the manufacture of the log, the sides were kept as square as possible, so as to avoid wane where it could be done consistently with no undue waste of thoroughly good timber.[1]

Too great a proportion of heart is undesirable, and logs which have large and deep bee- or worm- holes should be rejected, as the buyer looks on both with suspicion, and great waste is caused if the latter have to be converted into boards. Cargoes should also resemble one another more closely than they do at present. This could readily be effected by placing in each the same proportion of defective logs, but the percentage of such ought to be kept as low as possible.

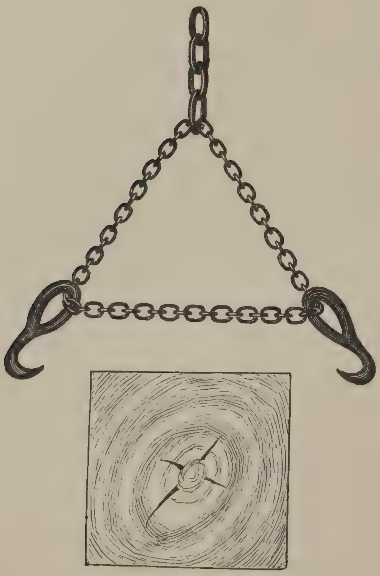

FIG. 6.

Under the present system of making each cargo maintain the usual percentage of "A," "B," and "C" piles (*i.e.* of logs 15 inches and upwards, from 12 to 15 inches, and below 12 inches, on the side, all being 23 feet or upwards in length), little care is taken to keep the average quality of a cargo up to some recognised standard. Increased attention to this matter would be a step in the right direction, more especially if along with the quality, the average size of cargoes could be maintained, as those consumers who buy from cargoes which are said "to arrive," would then be less afraid of the risk of getting their supplies from an inferior consignment than they are under present arrangements. By the Clyde shipbuilders, at all events, this would be much appreciated, as teak is not sold at that port according to the pile, but in "pages," the whole cargo being averaged so that each "page"—or twenty logs—contains the average in cubic and lineal feet of the whole parcel; thus, if a cargo averages, say, 27 lineal and 42 cubic feet per log, the average of each "page" will be the same.

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[1] Since this paper was written, the author observes that a marked improvement in this respect is noticeable in cargoes recently imported.

The attention of consumers should be more particularly directed to the short girthy timber, as it now forms a large proportion of every cargo, it being, as regards quality, the best part of any individual parcel. The reason of this is not far to seek. These pieces are least of all affected by shakes, if the heart-shake, which does not cause much waste in conversion, is excluded, as a log varying from 20 to 28 inches square contains so much timber that what is necessarily excluded to cover the heart forms but a small percentage of the whole. Many shipbuilders now prefer "shorts" to longer pieces on this account, and by selecting all the longer logs of the short girthy type—for example, those varying from 18 feet to the maximum, 22½ feet—for deck plank purposes, find it more profitable in the end, the remainder being specially suited for conversion into what is required for joiners' purposes. It is however in many cases impossible to use such lengths for decks, if a longer average be specified in a contract, but as the shipbuilder usually has such details almost entirely in his own hands, it would be well worth his while to give this timber more attention so long as it is shipped in such quantities as it is at present.

Importation of teak in the form of planks is also carried on, and this is beyond doubt the cheapest way in which the consumer can purchase this class of timber. Being as a rule absolutely free from defects, these planks require but little dressing, and if the consumer finds sizes suitable for his work, the saving effected, as compared with cutting from logs, will not be less than 25 per cent., apart from the cost of converting the latter. Such planks can be profitably used for gunwales, bulkheads, etc., when they are too thin or narrow for other purposes.

It may finally be noted that one or two samples of what is termed "selected Indian" teak logs have recently been discharged in the Clyde. These logs represent timber such as is specially selected for the Indian market, and therefore somewhat defective in many respects. In size they are much larger than "first-class" timber, and being considerably less in price, may be profitably worked up for many purposes.

IV. THE PRICE.

The price of teak has hitherto fluctuated so much, according to the demand, that it is impracticable to lay down any method by which, in the future, this fluctuation may be overcome. The fact that to deal largely in this wood requires a very large capital has beyond doubt deterred many from entering the field as wholesale traders; but this is not the most important cause of what consumers term "the high price of teak." On the contrary, this is to be found in the fact that the business is in the hands of a very few powerful and wealthy firms at the shipping ports, who, by carefully watching the condition of the shipbuilding industry of Great Britain and the Continent, can so control the market that a decline in this industry instantly witnesses a decline in the supplies. Their power in this direction is not to be wondered at when it is remembered that the difficulty of obtaining labour in Burmah —such a thing as a glut in the labour market being unknown there—offers them little inducement to prepare a large quantity of timber for the home market when it is not immediately wanted. Moreover, the method of obtaining leases of the forests from the native chiefs is fraught with corruption, and identified with the liberal use of backsheesh. When the lease of a forest runs out, the competition for it, if it produces timber of good quality, is so keen that it is easily let at its fullest value, and in order to turn the timber thereon to account profitably, the lessee may conceive the desire of obtaining supplies from the other most important forests as well. To do this he will willingly pay a high price, hoping thereby to create for himself a monopoly in the home market, or to rush up the price of native supplies, so as to place the other merchants on the same footing as himself as regards the cost of their raw material.

In these circumstances the consideration of "the price of teak," from the consumer's standpoint, clearly resolves itself into a problem as to how he can best buy this timber compatibly with getting the highest standard of quality and size.

The Clyde has generally proved to be the cheapest and best market for consumers to buy in, and those at a distance from it are only prevented from availing themselves of this condition of things by the cost of transit to the place where the timber has to be converted. While in the beginning of the year teak was selling in Moulmein at from 105 to 145 rupees[1] per load for square timber of first-class quality, varying from 20 to 30 feet long and from 10 to 24 inches on the side, and at 130 to 200 rupees per load for squares from 20 to 45 feet long and from 14 to 18 inches, second quality timber being from 85 to 100 rupees per load, it has in the Clyde only exceeded £15 per load by a few shillings. In Liverpool, on the other hand, first quality timber could not be obtained for less than 20s. per load in advance of the Clyde quotations, while in London and on the Tyne it obtained from £15, 10s. to £17 per load. One reason may be given for the low price of teak in the Clyde as contrasted with other ports, namely, the fact that the Clyde, as being by far the largest consumer, naturally provides the most steady outlet for his supplies to the exporter, who accordingly forwards a stock usually more than sufficient to meet the ordinary demand. During 1873-74 the price of teak was steady at from £15, 10s. to £16, 10s. per load.

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[1] Rupee = 1s. 8d.

Owing to a great and comparatively sudden depression in trade of all kinds during 1878-79, leaving a heavy stock in the market, it fell to from £13 to £10, 10s. per load, but gradually recovered itself when a revival took place, until at the end of 1883 it was again sold at from £15, 10s. to £17. Although a marked decrease has taken place since that time, it is doubtful if the price will fall much below £15 per load, exporters being very firm at from £14, 15s. to £15, 5s. for cargoes on their way or now being loaded.

Doubtless if the exporter finds that, owing to a small demand, or to some other cause, he is unable to obtain his quotations, he will modify his price, but this cannot always be relied on, because he can retail the cargo himself, and by stopping further chartering diminish the quantity exported on his part, so that when a fresh demand occurs he may have a large supply ready for shipment.

Hence, unless the consumer is prepared to lease a small forest, sawmill, etc., abroad on his own account, it is not within his power to alter the state of matters which prevail; but there is one way in which he can place himself on the best possible terms in purchasing, and that is by buying ahead for his future requirements when the price is decidedly low. In this way his stock, when he comes to use it, will have increased in value, and unless some very extraordinary circumstance takes place to cause a further depression, he cannot lose, as teak can be kept for a very long time—two or three years—without deteriorating in quality in any degree. Moreover, he thereby guards himself against a rise in price, which a large demand for timber from stock must cause, and at the same time buying ahead—*i.e.* "to arrive"—means buying cheaply, as an inducement is thereby offered to the merchant to sell low, because he knows that he will not be thrusting a large quantity of timber on the market so as to create a supply out of proportion to the demand.

There is yet another and very important inducement to the merchant to accept a much lower price for timber "to arrive" than for that lying in stock, namely, the saving of necessary expenses connected with storing and retailing, together with the interest on the value of the consignment—a very important item in transactions involving such a large amount of money as a teak cargo does. This system too may be said to attract shipments to the market, for, if the merchant has no "forward sales" to implement he need not ship his timber, and the consumer must needs, when he is in want of it, pay the merchant's own price.

It is a very difficult matter to say what teak should cost per load "*ex* ship," at any of the principal ports, as the price must fluctuate with the freight, market, and other minor considerations, but calculating from the average price paid for it for many years past, one would be justified in concluding that from £14, 5s. to £15, 5s. per load would be a fair standard for an average parcel. It has been found that a fall to much under the former, or a rise to much beyond the latter, of these figures, has never been permanent. It might, however, happen that a permanent advance in price would take place, and be quite justifiable.

V. THE BEST SUBSTITUTES FOR TEAK FOR SHIPBUILDING PURPOSES.

For shipbuilding purposes teak is undoubtedly the most valuable wood at present in the market; oak alone may be said to rival it, but there is a very important difference between these two classes of timber—the former containing an acid which destroys iron, so that when used for shipbuilding purposes the fastenings must be effected by copper nails and bolts, the latter possessing an essential oil which preserves iron.

Prior to the introduction of teak, oak was very largely employed in the construction of ships, but when iron began to be used for this purpose the demand for oak gradually diminished until the present time. Teak, moreover, being a tropical timber, is well adapted for withstanding the heat of the torrid zone, and so came to be more extensively employed than oak, and in looking for substitutes this important qualification cannot be lost sight of.

Among these substitutes we might first expect to find many species of oak, which, like teak itself, are not uncommon in Burmah, yet only one or two of these have been introduced to the home markets, where they found but little favour among consumers, principally owing to the fact that their prices did not fall below that of teak so far as to insure their adoption.

The Ironwood, or Pyengudu, is another native of Burmah, well worthy of notice. It is of straight growth, often rising to a height of 70 or 80 feet clear of branches, and of very large circumference. It yields timber in the log from 12 to 24 and even 30 inches square, and of great lengths. "The wood is of a reddish brown colour, hard, heavy, tough, strong, rigid, and frequently possesses some figure in the grain, which has the appearance of being both waved and twisted; its pores are filled with a remarkably thick glutinous oily substance, which oozes out upon the surface after the wood has been worked, leaving a clamminess which cannot be completely got rid of until the piece is thoroughly seasoned. This oily substance has probably a preservative property about it, and may be conducive to the durability of the timber. It is a favourite wood in the East for works requiring strength and durability, and, without doubt, the samples I met with all looked remarkably well, and seemed fit to be employed in any work of construction where great strength is required. It is heavier than water, and more indestructible than iron."[1]

Like the teak tree, ironwood possesses the heart-shake to a greater or less extent; but, unlike the former, it is not attacked by the white ant.

The following trees, which are also natives of Burmah, are remarkable on account of their compact and fine texture, their good quality and great durability, having been long used in that territory, and in works of construction, although, as yet, they are scarcely known in this country. They are the Padouk, of a deep red colour; the Parewah and the Penthityah, both of a dark reddish brown colour; the Kammone, the Annan, and the Kamonpur, all reddish, but rather paler than the Padouk; and the Thingan, which is much heavier than teak.

Certain Australian trees, such as the Tallow-wood and the Jarrah, also possess many of the distinctive properties of teak. The latter is remarkable for its durability. Its wood is said to be very indestructible, and it is not attacked by insects, as it contains a substance which acts as a poison to insect life. It is very strong, of a close grain, slightly oily and resinous in its nature, works well, takes a fine finish, and is by shipbuilders in Melbourne considered superior to teak, oak, or any other wood. It can be supplied at a cheaper rate than teak in the log, and at half its price in scantlings. Jarrah and Thingan have been classed with those timbers named in line 3, Table A, of Lloyd's rules for the construction and classification of ships.

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[1] Laslett's *Timber and Timber Trees*, chap. xxi. pp. 129, 130.

All the above-mentioned woods, which are well worthy of the consideration of shipbuilders in this country, may be easily procured through dealers in teak.

The Greenheart and Canadian White Pine (yellow pine) are also well known, and form fair substitutes for teak. The former is, unfortunately, very liable to split when iron bolts are driven into it, and is therefore unsuitable for decks and deck-houses; the latter, on the contrary, is largely used for such purposes, but it is liable to split when exposed to a tropical sun.

In conclusion, it is to be noted—(1) that the quality of teak is a matter of the greatest moment, and that price and size are alike subordinate to it; (2) that the maintenance of the supply tends to be insured by the fact that the export trade is in the hands of a few firms, whose interest it is to prevent reckless felling; (3) that the extension of the area covered by teak forests, and the careful oversight of those that have been cleared, are the best means of bringing about a reduction in price, by insuring a larger supply; and (4) that, at the present time, a more careful selection of cargoes might be effected without involving any marked increase in the market value of this most important commodity.

XIV.

NOTES ON THE RAVAGES OF TREE AND TIMBER DESTROYING INSECTS.

BY J. ALEXANDER, *Kirklees Estate, Uda Pusalawa, Ceylon.*

THE following descriptions and personal observations on the common noxious insects of India and Ceylon treat only of the most destructive species and their parasites.

1. *Pseudococcus adonidum,* the White or Mealy Bug, is identical with the species found in Europe. The insect is of a light dirty brownish colour, slightly hairy, very minute, being about a quarter of an inch long, and resembles a May-fly. The eggs are laid in a white cottony substance; they are oval in form, and of a yellow colour. It is preyed upon by the larvæ of wasps and beetles. It often occurs upon the roots of coffee-trees that have been destroyed by the white grub. It lives on the roots as well as on the branches of trees, but its favourite abode is upon vines, roses, and other climbers grown on a sheltered wall.

2. *Lecanium coffeæ,* the Brown or Scaly Bug, is closely allied to the lac insect, *Coccus lacca,* of India. It is common all over the world, and is much infested by very minute parasites of the most brilliant metallic colours. The bug is found in all stages of development throughout the year, its propagation being continuous. The eggs are oval in form and of a pinkish colour. Trees attacked are always visited by ants, which do not come to eat the bug itself, nor to drive it away, but to procure a certain saccharine fluid which it secretes. The remedies resorted to in England by gardeners to destroy bug on fruit-trees cannot very well be carried out upon an area of coffee.

3. *Lecanium nigrum,* the Black Bug, is shield-like in form,

and is larger and flatter than the brown bug. Its colour varies from deep brown to black. The test, seen through a microscope, is found to be composed of minute compartments. As soon as the bug is established on a tree, it becomes covered with a fine black tissue, which blackens the leaves and other parts of the tree. This tissue, on examination, is found to be a fungus, *Syncladium nietneri.* The number of eggs produced by a female is about five hundred. They are like dust, and are carried about by birds and insects, or by the wind. When deposited in a favourable place they soon hatch.

Some seasons ago planters were alarmed by the blackness of the coffee throughout a whole district of Ceylon, but the pest has since disappeared from the locality, although during last year it overran Matale, which is one of the oldest coffee regions and one which it had never before visited.

A tree thus attacked suffers from loss of sap, and partial starvation. It soon becomes exhausted, and ceases to produce any crop. The bug seeks out the most sheltered parts, such as young shoots, the under sides of leaves, and the clusters of berries. Successful experiments have been carried out to check this pest, by scattering fresh-burnt lime all over the trees and on the adjoining ground. Good results have also been obtained by tying *mana*-grass round the infected plants, in which case the smell of the essential oil contained in the grass proves remedial. The black bug generally prefers damp localities, but attacks all plants and trees alike.

4. *Strachia geometrica* is an insect of oval and plump form, and of a yellowish colour. It is marked on the upper side with grey and orange. It is allied to the green or fœtid bug. It feeds upon the juice of young berries, and it sometimes does considerable damage to vegetables by destroying the buds.

5. *Aloe lactinea.*—The caterpillar is black, and thickly covered with long brown hair, thereby resembling the "woolly bear," or caterpillar of the *Aretia caja* in England. It is found in dry weather, and is very destructive to young vegetation.

6. *Orgyia Ceylonica.*—The caterpillar is brown in colour, its under side and head being reddish; it is covered with yellow hair, and is furnished with two long, slender, horn-like tufts of dark hair on either side of the head, and another behind like a tail. It

spins a cocoon, in which the chrysalis rests for two weeks. The female moth is an ugly, maggot-like insect, with dirty yellow scale-like wings covered with black hair. The male is lively, and provided with brown wings, which are variegated with black and white. This caterpillar is common in cultivated fields during hot weather.

7. *Euproctis virguncula.*—The caterpillar is hairy, black in colour, and variegated with red spots. The moth is pure white, with black eyes. During dry weather it is very common on grass-covered ground. A field of cultivated grass may be eaten down to the roots by this pest.

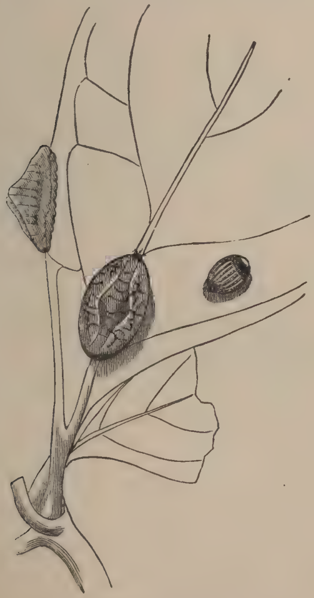
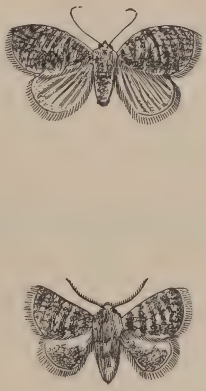


FIG. 7.—*Narosa conspersa* (larvæ).



Narosa conspersa.

8. *Trichia exigua.*—The caterpillar is brown above and grey below, variegated with red and yellow lines. Behind the head two fleshy ear-like protuberances occur. It is found on fruit and forest trees.

9. *Narosa conspersa.*—This caterpillar (Fig. 7) is not often seen. It lives on the under sides of leaves, and feeds at night.

10. *Limacodes graciosa.*—The caterpillar has a whitish back, green sides, and a brown head. It encloses itself under a thin

tissue in a kind of cocoon. The chrysalis rests three months before the moth escapes. The moth is very handsome, being of fine green colour above, with a dark brown body. The caterpillar is very destructive to the tender leaves of young plants.

11. *Zeuzera coffeæ*, the Red Borer (Fig. 8), is fortunately not so abundant. A heap of wood dust at the root of the tree indicates that the caterpillar is carrying on its destructive work. The chrysalis rests three months before the moth escapes. It is about an inch and three-quarters across the wings, which are of a white colour and spotted with blue. The damage done is small compared to that effected by the white borer.

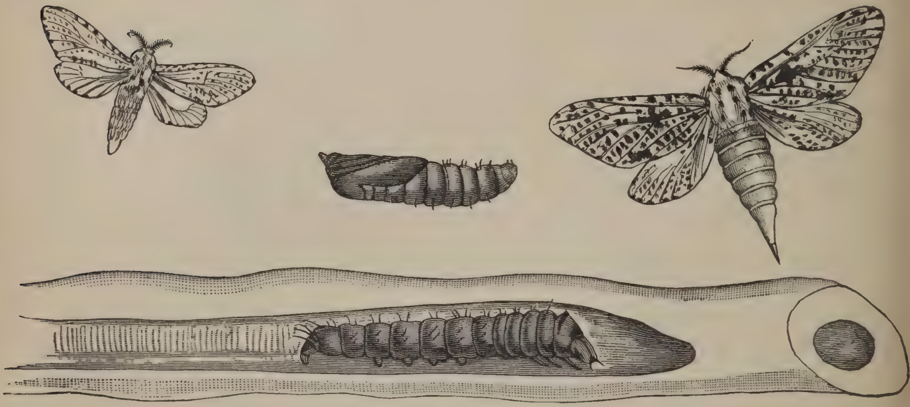


FIG. 8.—*Zeuzera coffeæ.*

12. *Agrotis segetum*, the Black Grub, is well known all over the world. In agricultural districts it is sometimes very destructive. The caterpillar is very common, and lives in the ground, but comes forth at night to feed. The damage done in young plantations is often serious. They not only attack trees, but all sorts of vegetables and flowers. Nurseries, potato and cabbage fields, alike suffer from their ravages. The plants are bitten right off and partly dragged under the ground.

13. *Galleriomorpha lichenoides* (Fig. 9) is a little moth about three-quarters of an inch across the wings. It is of a greyish

brown colour, and is often found on cultivated trees where its larva feeds.

14. *Boarmia leucostigmaria.*—The caterpillar of this moth, from its way of moving, is called a "looper." When at rest it stands straight on end, and resembles a twig very closely. It feeds upon the young foliage of forest trees.

15. *Tortrix coffearia* is a moth one inch across, of a light brown colour, and shaped like the section of a bell. The larva is one inch long, of a brown and green hue. It lives on the leaves of plants which are drawn together, and inside these leaves it resides.

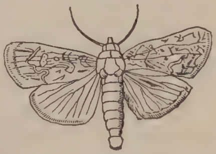


FIG. 9.—*Galleriomorpha lichenoides.*

16. *Gracilaria coffeifoliella* is a minute moth, of a blackish colour above, with silvery grey spots below. Its larva mines the leaves with ugly white lines and blotches, which are frequently seen. It gets under the epidermis and eats out the inner parts of the leaf.

17. *Elachista coffeella* is allied to the above. The larva is of a silvery white colour, and is the greatest enemy of the coffee-tree in the West Indies.

18. *Termes fatalis*, the White Ant.—The mischief done by this most persistent species is well known all over the East. Everything that comes within its reach is doomed. In some of the warmer parts of India it is found at an elevation of 5000 feet, but on an average it does not occur above a height of 4000 feet. An ordinary ant-hill, which is of roundish form, is often eight feet high in the low country. When a house remains unoccupied for a time, the ants soon raze the building to the ground. In dry weather they attack living plants and trees; and as they work, if possible, in the dark, they cover the stem of the tree with a shell of clay, under which they eat off the outer bark. Trees that shed their bark annually do not suffer; still the coffee-tree and many others are damaged to a certain extent. In the chambers of their nests flourishes a microscopic fungus, forming a beautiful silvery crystalline-like tissue. All wood-work about buildings requires constant attention. Tar and kerosene oil check their ravages for a time.

19. *Formica smaragdina*, the Large Red Ant.—Of the real ants there are about ten species, large and small, red and black. They feed on flowers and fruit for the sake of the sweet saccharine matter they contain. These ants are very fierce, and their bite is painful, so that the natives will not approach their nests, which are made of dry leaves hung from a branch of a thick shaded tree.

20. *Phymateus punctatus*, the Locust (Fig. 10), possesses a scarlet abdomen, but is of a yellow and bronze colour above. It is beautiful, and is well known in the East. It appears to attack all agricultural produce that comes in its way, doing great damage to grain crops, cocoa-nut, and other plantations. The larvæ are as destructive as the perfect insect.

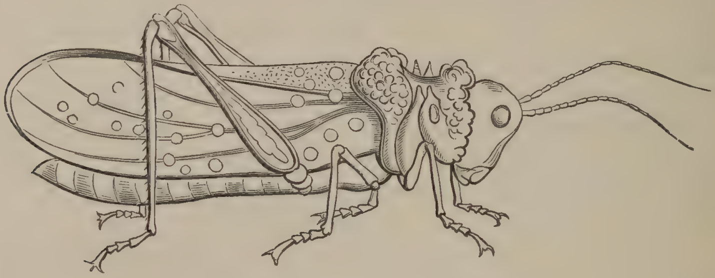


FIG. 10.—*Phymateus punctatus.*

21. *Aneglonycha mucida*, the White Grub.—The larvæ of the Cockchafer family are known to remain in an imperfect state for years. They are by far the greatest enemies of the coffee-tree, in one year hundreds of acres of fine coffee being sometimes destroyed by them, as the grubs make their way from one end of the estate to the other. Men are employed to dig up the soil at the foot of the tree, and pick out all the grubs they can find. Lime, salt, and other manures may be applied as remedies, but in many cases the trees never recover, as the grubs eat all the feeding rootlets, and in wet weather are found near the surface. They also infest gardens, nurseries, and young plantations, devouring everything where they go.

22. *Xylotrichus quadrupes*, the White or Indian Borer.—The ravages of the larvæ of this beetle are well known among the coffee estates of Southern India, and some years ago the

Madras Government commissioned Dr. Bidie to investigate and report on the subject. The insect, which was first discovered on Kirklees Estate in Ceylon, lays its eggs upon the stem of the tree, whence the young larvæ find their way into the interior. Fortunately for Ceylon, the White Borer has only been found on a few estates in other districts. It confines its ravages to localities that are warm and sheltered. It has proved fatal to many fine coffee-trees on Kirklees Estate, the annual loss amounting to about one per cent. The stem of the tree is bored, and the fact that the plant can live and go on bearing heavy crops for years is surprising. Recently I have discovered, and now agree with Dr. Bidie, that shade is the only remedy for the coffee, plants thirty years old under the shade of Jak-trees being still splendid.

23. *Arhines destructor*, the Green Weevil, is common during dry weather. Its front is covered over with closely set gold-green scales. When these insects disappear the ground may be seen strewed with their bright green elytræ. Sometimes they are very injurious to green crops, and appear to frequent the same place every year. They consume almost every leaf.

24. *Sitophilus oryzæ*, the Rice Weevil (Fig. 11).—The family of the Weevils is one of the most extensive among the beetles, and many of its members in Europe and Asia do much damage to agricultural produce. Rice, Indian corn, peas, and beans are soon rendered unfit for human food when perforated by this destructive insect.

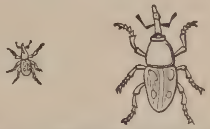


FIG. 11.—*Sitophilus (Chalandra) oryzæ.*

25. *Cylas tureipennis* is a very destructive weevil to young vegetation in warm countries.

26. *Sphœnophorus planipennis* sometimes does serious damage to cocoa-nut plantations in the East.

27. *Odontolabis Bengalensis*, the Black Stag-beetle, is very plentiful all over the East, but it cannot be considered very destructive. It generally lives in resinous trees, into which it bores holes in search of resin and gum. It often occurs in decayed and fallen trees in the forests. It prefers to live at low elevations, in warm and dry parts, and is seldom seen near dwelling-houses.

28. *Alaus speciosus,* the Black Carpenter Beetle (Fig. 12), is very destructive to timber in houses. It bores a hole about an inch in diameter through beams and rafters. It is easily caught, and its holes can be closed up with a tarred plug.

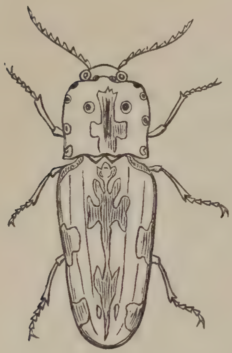


FIG. 12.—*Alaus speciosus.*

29. *Xylotrupes Gideon* (Fig. 13) is a large brown rhinoceros beetle. The male bears a forked horn on the head and a corresponding one on the thorax. During the imperfect stages of their existence they live in dunghills.

30. *Leucopholis pinguis,* the Cockchafer Beetle.—Agriculturists in the East may well regard this as their greatest pest. It lays eggs which produce white grubs. Millions may be collected between the hours of 6 and 8 P.M. The beetles come from the forests during the months of January, February, March, and April. Cinchona and other trees serve as their resting-places.

31. *Daphnis verii,* the Oleander Moth, is one of the largest and most beautiful moths of tropical countries. It comes forth in warm weather, always appearing at night, and often coming into houses to the light. Its larva is the Cinchona caterpillar. One moth is said to lay as many as five hundred eggs.

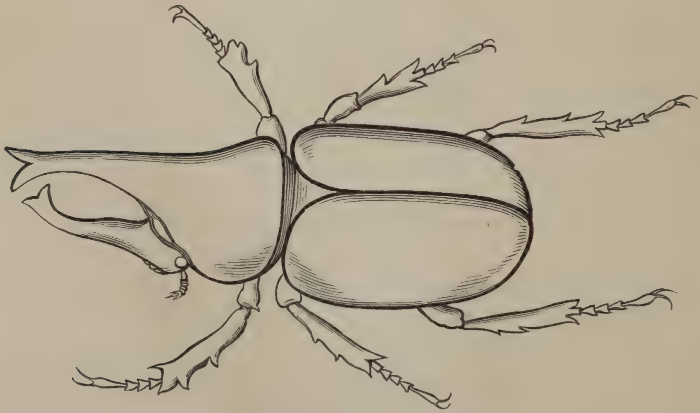


FIG. 13.—*Xylotrupes Gideon.*

The Cinchona caterpillar effected very serious damage some years ago on young plantations in India and Ceylon. During the last few years, however, it has not been so abundant. It is most plentiful during April and May. Every leaf, and even the young twigs, may be eaten in one night from trees of four or five years' growth. Hand-gathering carried on by a number of boys for a few days soon clears the plantation of this pest.

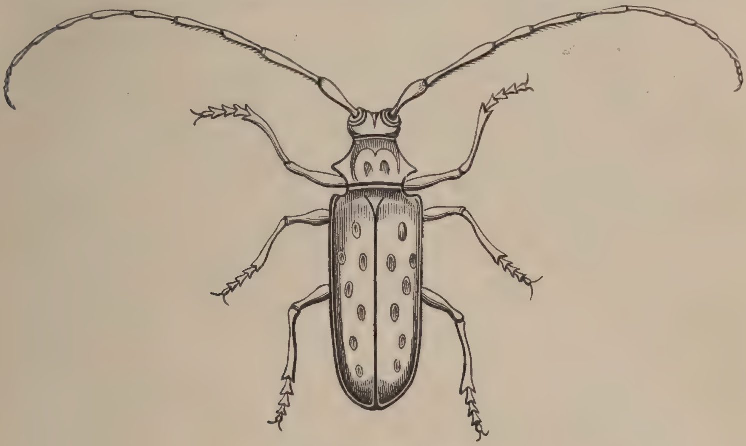


FIG. 14.—*Batocera rubus.*

32. *Batocera rubus,* the Cocoa-nut Beetle (Fig. 14), is the greatest plague against which cocoa-nut planters have to contend. The larvæ are laid in the centre of young trees, and in three months the beetles commence their work. They bore a

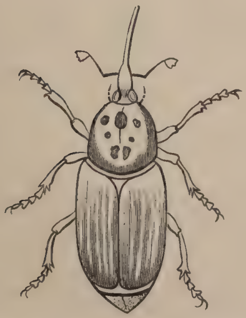


FIG. 15.—*Rhyncophorus ferrugineus.*

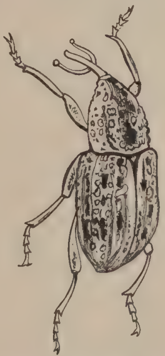


FIG. 16.—*Sipalus gigas.*

series of holes through the centre, and eat the young leaves. The tree soon appears unhealthy, and dies. In old plantations many fine trees are seen towering high without their feathery tops; and the young trees have to be periodically examined. The natives have many methods for destroying this pest.

33. *Rhyncophorus ferrugineus* (Fig. 15) occurs in the hotter parts of the island, where its ravages are confined to timber trees.

34. *Sipalus gigas* (Fig. 16).—This beetle is found in the low country forests, and is classed among the timber destroyers.

35. *Ægus acuminatus* is a beetle which is very often found under the bark of growing trees.

XV.

CHARCOAL—ITS MANUFACTURE AND USES.

By A. D. Webster, *North Wales.*

The practice of charcoal-burning on the small scale to supply fuel for domestic purposes is not so general on estates as one might reasonably expect it to be. When the many other valuable uses to which charcoal can be put are considered, the importance of its manufacture from an economic point of view is clearly seen.

In the following description of the manner in which charcoal-making by the oldest and simplest of all processes has been carried on for many years on an estate, the writer will not enter into any question of the chemical differences between wood and charcoal, or of the manner in which the change from one to the other is effected, and he will not describe the numerous modifications of pit-burning employed in this and other countries, nor the newer modes of conducting the charcoal manufacture on the large scale by destructive distillation. What is aimed at is to give a description of the one process which can be carried on anywhere and by any one.

The first requisite in charcoal-burning is a piece of ground sheltered from the prevailing winds, and in a position to which easy access with wood can be obtained. A shed has to be constructed in which the charcoal may be stored, and part of which is reserved for the accommodation of the men employed at the work. The wood is carted in at any time when it is obtainable, and when horse-labour can be conveniently spared from other parts of the forest work. All kinds of hard woods not under two inches in diameter, poplar and willow being generally excepted, may be used. The larger pieces of firewood, and, in general, any unsaleable timber which may be come across in the regular course of thinning, are used for the purpose.

Amongst our timber trees, oak, ash, and beech produce the largest quantity of charcoal, and that of a superior quality. The charcoal produced from some shrubs, especially from *Rhamnus frangula*, is much in request for the manufacture of gunpowder.

The wood is sawn into pieces two feet in length, which are split, if required, to about four inches square, and when a sufficient quantity has been cut up for two pits, the building of these is proceeded with.

It is better to burn two pits at the same time, as both can be attended to during the charring process as conveniently as one, and it is unnecessary for the men to sit up at night to watch each separately.

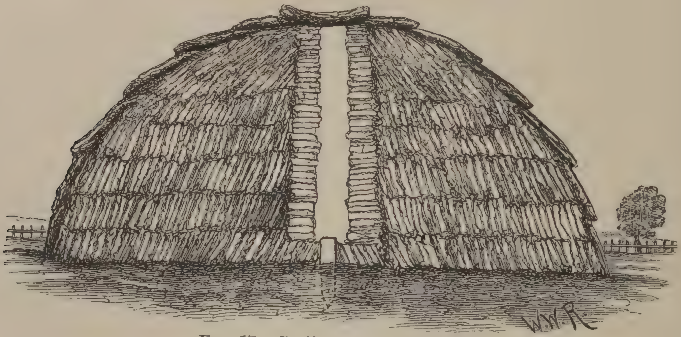


Fig. 17.—Section of a Charcoal Pit.

The "pits," one of which is shown in section in Fig. 17, are usually made of a conical shape, twenty-one feet in diameter, and about nine feet in height, and the mode of constructing them is as follows :—A strong stake is driven firmly into the ground and left protruding about a foot. Around this are placed small pieces of dry ash of equal length, and standing as close to the upright stake as possible ; around this another layer is placed in the same manner, and this is continued until a circle five feet in diameter is obtained. A circle one foot in diameter, and having the top of the stake formerly driven into the ground as centre, is next made by placing the wood horizontally on the upright pieces and side by side, the ends of each piece being placed at the circumference of the circle already made, and directed towards its centre. Layer upon layer is built in this manner until the pit is of the required height, the wood used here being dry pieces of ash two feet in length, but split rather smaller than the ordinary pieces. A sort of chimney is thus formed, by means of which the pit is fired. Outside the core the wood is placed on end and reclining inwards, this being continued until the pits are of the required size. When the building is completed the pits are covered with newly-cut turf, the grassy side placed innermost, beginning at the base and working towards the top, each line of turf overlapping the previous one by a few inches. The circular hole or chimney is left open for firing. Before turfing the top half of each pit, it is carefully examined, and any crevices between the wood packed full of small pieces of turf and sawdust to exclude the air. The turfs are cut about a foot in width, and of any convenient length. The quantity required for two pits of the dimensions stated is seven loads.

When the pit is satisfactorily covered it is fired by dropping a couple of shovelfuls of burning wood and some dry pieces of pine or ash into the opening left at the top; the top turf is then put on, which effectually shuts up the chimney, and the process of charring commences. The smoke is first seen issuing from the lower half of each pit, where the chinks were not packed with sawdust, and ultimately it escapes from the whole surface.

Constant attention is required day and night during the period of burning, especially should the weather be stormy, as the wind, by striking on a particular part of the pit, causes that side to burn more rapidly, and fall in. When this occurs the hole must at once be filled with rough logs, which had been set aside for the purpose when splitting the wood, and re-covered with turf.

When the weather is mild the pits burn uniformly, require but little attention, and produce the finest charcoal. The time required for burning varies from seven to nine days, according to the meteorological conditions, being greatest in dry and mild weather. As the charring proceeds the turf gradually disappears until only a slight covering of burnt earth remains. When the pits have burned out and become cool, it is found that they are reduced to rather less than half their original size.

The charcoal is extracted by means of a rake resembling a light drag, but having much finer teeth, and after it has become quite cold, it is stored in the shed until required for use.

The very finest charcoal—far superior in quality to what is generally sold—is produced by this method. The expenses connected with making it are, no doubt, a little heavier than where the retort is in use, and the bye-products can be utilised; but it must be borne in mind that by the method of pit-burning charcoal can be made at any place where timber is being felled without extra expenses, save that of the cartage of the charcoal, whereas in using the retort the wood must, in most cases, be conveyed to the place where it is erected.

The cost of producing charcoal by the above method will vary very considerably, much depending on the distance the wood has to be carted, and on the cost of labour in the district. With everything in readiness, from 7d. to 8d. per bushel may be considered a fair price to allow the charcoal-burners. On most estates it will, however, be desirable to select an out-of-the-way place in which to burn the charcoal, and all materials in connection with the work must be conveyed there. At Penrhyn Castle in North Wales all expenses in connection with the production and delivery of charcoal has been carefully noted by the writer each year, and the actual cost is found to be about 1s. 9d. per bushel.

The following is a detailed statement of the total cost of producing 1755 bushels of charcoal :—

Cost of burning 1755 bushels at 7d.,	£51	3	9
Man's time cutting turf for covering pits, 9 days at 2s. 8d.,	1	4	0
Cartage of same to pits, 6 days at 10s.,	3	0	0
286 loads of wood at 6s.,	85	16	0
Cartage of charcoal from pits to storing-shed, 3 days at 10s.,	1	10	0
Man's time assisting at same, 6 days at 2s. 8d.,	0	16	0
Man's time riddling charcoal before being sent to Castle for consumption, 20 days at 2s. 8d.,	2	13	4
Cartage of same to Castle, 20 days at 2s. 6d.,	2	10	0
Two men's time with same, or 40 days at 2s. 8d.,	5	6	8
	£153	19	9

This is equivalent to a cost of 1s. 9d. per bushel.

The uses of charcoal, for estate purposes, are very numerous, for horticultural, agricultural, and other departments.

From remote antiquity charcoal has been used as a fuel, and for many purposes it is still unsurpassed. It is by far the cleanest solid fuel known; it burns steadily, gives out a great amount of heat, and lasts well. On account of its smokelessness it is invaluable for cooking, and it is also admirably suited for use in greenhouse and other stoves. It is not adapted for heating apartments on account of the poisonous gas (carbonic oxide) produced in its combustion, and the danger, most apparent when the charcoal is burnt in an open *chauffeur*, is not obviated by using it in a stove, as carbonic oxide has the power of diffusing through red-hot iron.

In gardening, charcoal is largely used for potting purposes, for vine borders, and for flower-beds; and in the form of dust it is the best material for packing bulbs for transmission to a distance.

Perhaps the most important of the uses to which charcoal can be put about a house or estate is that depending on its extraordinary power of absorbing gases. It is a perfect deodorant, a preservative of food and all animal substances, and a valuable disinfectant. The gases most readily absorbed by charcoal are those which are most prejudicial to health, and which are most frequently produced by putrefactive changes. In the pores of the charcoal they are destroyed by union with the oxygen condensed from the air. The fact of its being absolutely non-poisonous and perfectly odourless puts it before all other disinfectants.

XVI.

BYE-PRODUCTS.

UTILISATION OF COPPICE AND OF BRANCHES, AND OTHER FRAGMENTS OF FOREST PRODUCE, WITH THE VIEW OF DIMINISHING WASTE.

BY G. S. BOULGER, F.L.S., F.G.S., *London.*

OF late years the general state of depression in agriculture, resulting in part from increased facilities for transit and trade between all producing countries, has caused greater attention to be turned to forests and woodlands as a source of profit. Though, in common with other trades, the British production of timber has been rendered far less remunerative than formerly by keen foreign competition, it can be shown that timber will yet, in many cases, yield a very fair return for capital.

This is not the place to enter at length into such a demonstration, but it may be pointed out that there is in the British Isles an immense area of land that either never has yielded, or at the present time does not yield, any agricultural rent, but which might become of value were capital invested in planting it with timber trees.

The forest-produce of Great Britain is mainly applied in the following ways:—

1. Ship- and boat-building, piers, bridges, etc., requiring much large and sound timber.
2. Building, scaffolding, etc.
3. Railway sleepers.
4. Pit props.
5. Fencing.

6. Furniture; mainly chairs of beech, yew, etc.
7. Hop poles and agricultural implements.
8. Bobbin-wood.
9. Fagots and firewood.
10. Charcoal for gunpowder, pitch, etc.
11. Bark for tanning.

In the first four of these branches, the produce of the forests of Scandinavia, for the present apparently inexhaustible, shipped at the very smallest modicum of profit to the producers, has almost driven British timber out of the market. The rent-charges on land, the costliness of labour and of overland transit in this country, may be contributing causes to this result; but it is also apparently the fact that the sending of crooked or heavily-shaped timber into the market by our foresters is another reason for the success of this important trade. It will probably be found in this, as in other branches of trade, that the best method of meeting foreign competition is by looking to increased economy of production, coupled with excellence of quality; and as in other trades, it is probable that the utilisation of waste substances and bye-products may prove the chief key to economical production.

Wood for fencing is generally produced in the immediate neighbourhood, and will not bear much expense of transit. It requires, moreover, good-sized timber, and although perhaps coppice with standards is the most remunerative form of sylviculture for the lowlands of England, we are at present mainly concerned with pure coppice.

It is doubtful whether the consumption of native wood in the manufacture of furniture can be readily extended; and, as hop poles, agricultural implements, and bobbin-wood are already locally among our most remunerative outlets for coppice produce, the main questions with reference to them are economy of production and utilisation of waste.

Though hops form a very uncertain and costly crop, the profits on hop-growing are so considerable that the extension of its culture should be considered by our farmers. Chemical substitutes for hops cannot be successfully used to the exclusion of the natural bitter, and English-grown hops can compete on favourable terms with foreign ones. The soil required is almost entirely the result of manuring, so that there can be little doubt that the plant might be grown in many districts where it is not at present cultivated; whilst the "bine" could be used in the manufacture of textile fabrics, as on the Continent, or of paper. An increased production of hops would increase the demand for poles, for which the Spanish chestnut, ash, and larch are largely grown in the south of England. Ash is also in constant demand for the handles of ploughs, spades, axes, and other implements, and is, like sycamore, the wood of which is considerably used by wheelwrights, a rapidly-growing tree. The cultivation of hornbeam for such purposes might also be extended, more especially on poor gravelly land. Bobbin-wood is a most useful means of disposing of small wood that might not be otherwise saleable; but its prices rule too low to bear the cost of transport from any distance. The same is true of fagots and firewood, so that, in a country so rich in coal as is Great Britain, it can seldom be remunerative as anything but a bye-product.

There are undoubtedly many trades not thought of by the timber merchant, in which considerable quantities of small woods are consumed; thus it is alleged by American statisticians that in the United States, besides 300,000 new telegraphic poles, and 3,000,000 cords of wood used in brick-burning, the making of shoe-pegs alone uses 100,000 cords of soft maple annually, that of lucifer matches 390,000 cubic feet of pine, and that of boot-lasts and tool-handles 1,000,000 cords of birch.[1]

Such facts suggest the possibility of a remunerative production of larger quantities of coppice woods; but, though in the sequel something will be said as to the cultivation of particular kinds of trees, our main topic is the utilisation of bye-products other than wood, or of wood not in the ordinary condition in which it is used.

It being man's highest intellectual function to utilise to the full all the latent powers of Nature, we may well direct our attention to such bye-products as bark, charcoal, wood-spirit, turpentine, tar, sawdust, leaf-manure, and wood-ashes.

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[1] *Journal of Forestry*, vi. 286.

BARK.

Bark is used for tanning, *i.e.* for the conversion of hides or skins into a strong, supple, impermeable, and durable material, known as *leather*, by the union of the albumen, gelatine, or collagen of their connective tissue, with a substance in the bark known as *tannin*, so as to form insoluble tannates. Tannin is widely distributed throughout the vegetable kingdom, especially in barks, fruits, and galls. It is characterised by a slightly acid reaction, an astringent taste, a bluish- or greenish-black colouration (ink), with ferric salts, the precipitation of gelatine and albumen from their solutions, and its union with them as above mentioned. Our knowledge of its exact composition is extremely limited; but it has apparently the empirical formula $C_{34}H_{28}O_{22}$; and since when boiled with dilute acids it yields gallic acid ($C_7H_6O_5$) and glucose ("grape-sugar," $C_6H_{12}O_6$), it is possibly a glucoside of tannic acid ($C_{14}H_{10}O_9$), $2C_{14}H_{10}O_9 + C_6H_{12}O_6 - 2H_2O = C_{34}H_{28}O_{22}$.[1] This constitution is however by no means thoroughly ascertained, for the tannins form a little-known group. Galls and kino are too costly for tanning purposes; cutch and gambir (*Terra japonica* and *T. catechu*) are vegetable extracts, useful in softening leather, and in hastening the tanning process, but only used in conjunction with other materials. Sumach leaves form a valuable material for white morocco leathers; divi-divi, the seed-pods of *Cæsalpinia;* "hemlock extract," a decoction of the bark of the hemlock spruce (*Abies Canadensis*); and "Mimosa bark" from the Australian "wattles" (*Acacia sp.*) are largely imported, but the chief British tanning material is oak bark. In France the young bark of the cork oak (*Quercus suber*) is largely used, and for fine leather that of the evergreen oak (*Q. ilex*); in the east of the United States the white oak (*Q. alba*), the *quercitron* (*Q. tinctoria*), and the red oak are employed, while California and the Western territories depend entirely on the chestnut oak for tanning purposes.

English oak bark, although not a valuable bye-product at present, may, in the future, increase in value, unless indeed the system of chrome-tanning succeeds, as is possible, in superseding entirely the use of bark of any kind. The annual home supply is estimated at from two to three hundred thousand tons, in addition to which some thirty thousand tons are imported from the continent of Europe. Though tanning with oak bark is a slow process, that of English growth certainly gives great solidity to the leather. Of the two native varieties of *Quercus robur*, the pedunculated oak (*Q. pedunculata*) always contains more tannin than the sessile-flowered (*Q. sessiliflora*), in the most favourable season, *i.e.* the end of April, the former containing nearly fifteen, the latter nearly thirteen, per cent. When coppice was largely grown for bark a rotation of twenty-four years was common, the stools being eight feet apart ; but trees are more productive in proportion at twelve than at double that number of years' growth. Branches down to an inch in diameter should be carefully peeled, since their bark contains a relatively higher proportion of tannin than that of the trunk. Since the ruling low prices for bark have made many foresters doubt the expediency of felling their oak in May, when the timber is almost at its worst, it may be well to bear in mind that French and Prussian experiments have shown that bark of good quality may be obtained at any season by steaming the wood. Air-tight receivers of thin plate-iron, holding about half a cord each, are filled with wood, and then steam at 170° C. is admitted for from one and a half to two and a half hours, according to the season, after which the bark peels easily.

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[1] H. E. Armstrong, *Organic Chemistry* (1880), pp. 304, 305.

Though undoubtedly the pedunculated oak will long be our chief English tannin producer, it should not be forgotten that willow bark is largely and successfully used in Russia for the best leather, and that the bark of young alder shoots, not a third of an inch in diameter, yields sixteen per cent. of tannin. This latter is recommended for use in conjunction with oak bark or "valonia." The bark of pine and larch is only used for roughly tanning sheepskins.

CHARCOAL.

The value of charred wood-fibre, deprived of its liquid and volatile portions by destructive distillation, for smelting and heating purposes, has long been recognised. Though now in

England, Belgium, and other coal-producing countries, cheapness of production outweighs considerations of quality, the value of Swedish iron is, probably with justice, attributed to its being smelted with charcoal; and many of the furnaces of the United States are as dependent upon the wood-supply as were those of Sussex in the sixteenth and seventeenth centuries. For charcoal-making the hard woods are mainly used; beech charcoal being preferred in the mineralogical laboratory.

In this country the chief use of charcoal is in the manufacture of gunpowder, for which purpose a highly inflammable quality, which is obtained from light spongy woods of various broad-leaved species, is generally required. It requires to be as free from earthy or mineral matter as possible, though no charcoal is absolutely pure carbon, generally retaining, as it does, some hydrogen and oxygen, as well as mineral ash. For this reason, though still largely prepared by the primitive method of pits or heaps covered with turf, charcoal is preferably manufactured in iron cylinders or retorts,—a method which is far more economical, and can yield a more uniform result. The inflammable gases distilled from the wood are conveyed by pipes into the furnaces below the retorts, so that an immense saving in fuel is effected, while the tar, pyroligneous acid, etc., are condensed and collected. The temperature at which the wood is charred exercises a great effect upon the properties of the charcoal. The higher the temperature the more completely are the hydrogen and oxygen of the wood driven off, and the denser and blacker is the resulting charcoal, while its temperature of ignition is also higher in proportion. Slack-burnt charcoal retains more volatile matter, is softer, reddish, more readily inflammable, and more hygroscopic. It is known in France as "*charbon roux*." It has been found by experiment[1] that, with 60 grains of saltpetre, 12 grains of each of the following kinds of charcoal give the number of cubic inches of gas (CO_2) in the table:—

"Dogwood" (*Rhamnus frangula*), . . .	82 cub. in.
Willow (*Salix alba*), ...	77 ,,
Alder, ...	74 ,,
Filbert, ...	72 ,,
Fir, chestnut, hazel, ...	66 ,,

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[1] *Encycl. Brit.*, 9th ed. vol. xi. p. 320, *sub voce* "Gunpowder."

The three first-named species are accordingly preferred for the purpose, though *Cornus sanguinea, Euonymus Europæus, Rhamnus catharticus,* and perhaps other species, are not uncommonly substituted for the alder-buckthorn, berry-bearing alder, or true "dogwood" of gunpowder manufacturers (*Rhamnus frangula*). This is a slow-growing shrub, being cut, when about an inch in diameter, and under ten years of age, in lengths of not more than six feet. It is grown in Prussia, Belgium, and Sussex; but might well be cultivated in other parts of the United Kingdom. It forms a very explosive powder, used for military small arms, and for sporting purposes. Willow and alder are of quicker growth, especially the former, and are cut when about four inches in diameter.[1] With reference to the use of the two last-named species an important point is that they can be cut in the spring, when their bark is in the best condition for tanning purposes.

Charcoal is also of great value as a filtering and deodorising agent.

VOLATILE PRODUCTS.

Besides a certain amount of tar, of which more anon, and the inflammable gases which, as has been stated, are utilised as fuel in the charcoal manufacture, even the smoke has proved of considerable value. It contains methylic alcohol, which also distils over from the retort in a liquid form, accompanied by acetic acid. This crude distillate is known as "wood vinegar," and is re-distilled and rectified over quicklime, yielding "wood-spirit" (crude methylic alcohol). The acid portion is then saturated with slaked lime, so as to form a solution of calcium acetate, which is evaporated, the salt being used in the manufacture of acetic acid and metallic acetates, especially that of lead, as a step toward the formation of white-lead.[2] The Honourable Dr. F. B. Hough describes[3] a charcoal iron-smelting factory in Michigan, where a cord of wood yields 42 bushels of charcoal, worth 7 cents per bushel, or 2·99 dollars per cord, besides 2800 cubic feet of "smoke," valued at over 30 cents, and the inflammable gas which supplies three-fourths of the fuel consumed. The "smoke" yields two gallons of wood-spirit, worth 85 cents (3s. 4½d.) per gallon in the Chicago market, and 200 lbs. of acetate of lime, worth 2½ cents (1¼d.) per lb. in Philadelphia. Thus the "smoke," for which 30 cents (1s. 3d.) are paid, yields 6·70 dollars (£1, 6s. 9d.), the total yield of a cord of wood being 9·69 dollars (£1, 18s. 8d.). These products are best obtained from dry hard woods, especially beech; but a yield of £2 per cord is certainly worth the attention of woodmen.

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[1] "Gunpowder," by Major W. H. Wardell, *Encyclopædia Britannica*, ninth edition.

[2] H. E. Armstrong, *Organic Chemistry*, pp. 151 and 254.

[3] *Journal of Forestry*, v. 64.

TAR AND PITCH.

The mixture of heavy non-volatile hydrocarbons known as tar, though obtained in small proportions in the destructive distillation of all kinds of wood, is yielded mainly by the roots, boles, branches, and waste timber of pines, especially *Pinus palustris*, *P. sylvestris*, and *P. pinaster*. It is mainly imported from the Southern United States, from Archangel, and from Riga and other Baltic ports. The pitch pine (*P. palustris*) covers extensive tracts, and springs up spontaneously in the disused cotton-fields of the Southern States, whilst the Scots pine (*P. sylvestris*) forms enormous forests in the north of Europe and in Siberia. The preparation of tar is still virtually the same as that described by Theophrastus in the fourth century before Christ. A hole is dug in the side of a bank, in which billets of wood are heaped up, and covered closely with turf or earth; a fire is then kindled from below, and the slow combustion causes the tar to exude from the wood, and flow out from the heap into barrels placed below to receive it. On distillation, tar yields wood vinegar, creosote, and oil of tar, leaving a residue of pitch. The black, brittle, glossy solid which we know as pitch, and which is mainly home manufactured, is usually obtained by simply boiling the tar, so as to drive off the volatile oils.

TURPENTINE, ROSIN, ETC.

In addition to being our chief sources of tar and pitch, the firs are the exclusive commercial source of the oleo-resin, known as turpentine. This is a solution of a resin in a volatile oil which exudes from incisions made in the stems of these trees. On distillation it yields from 14 to 16 per cent. of colourless essential oil, known as oil or spirits of turpentine ($C_{10}H_{16}$), the residue being rosin or colophony (the formula of which is probably $C_{44}H_{62}O_4$). The greatest quantity of turpentine imported is the produce of the pitch pines (*Pinus palustris*, or *P. australis*), the swamp pine, and *Pinus tæda*, the frankincense pine of Virginia, Carolina, and other Southern States; but a considerable quantity, imported from Russia and Sweden, is the produce of the Scots pine (*P. sylvestris*), and from the South of France, under the name of "Bordeaux turpentine," where it is obtained from the cluster pine (*P. pinaster*), and other species. "Strasburg turpentine" is obtained from the silver fir (*Abies pectinata*), and "Venice turpentine" from the larch (*Larix Europæa*). Canada balsam is a similar product from *Abies balsamea* and *A. Canadensis.* Frankincense is a rosin formed by natural evaporation. Two of these species, *Pinus sylvestris* and *Larix Europæa*, are already largely grown in this country, and the cluster-pine and silver fir are quite hardy. The cultivation of the former (*P. pinaster*), on the sand-dunes of the Landes of Bordeaux is a good example of the conversion of an originally merely protective measure into a source of profit from soil formerly worse than useless. Whether the felling of the forests of Southern France, by producing droughts, was, or was not, originally the cause of the arid, barren sands, certain it is that by damming up the natural drainage and shifting inland, these dunes produced swamps and wastes, the advance of which was only stopped by the binding roots of these pines. Originally planted with this protective object, their yield of timber, bark, turpentine, and tar has rendered them a source of profit, which should remind us that we have on our own coast-lines considerable stretches of similar sand wastes. A useful illuminating oil, containing from 80 to 92 per cent. of carbon, has been obtained by M. Guillemare from the resin from the Bordeaux area.[1]

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[1] *Journal of Forestry*, i. 376.

MINOR PRODUCTS.

Besides such substances as bark, charcoal, wood-spirit, acetic acid, tar, pitch, turpentine, and rosin, which are important articles of commerce, chemical discovery has demonstrated in the past, and may be expected to show still more frequently in the future, the presence of substances in trees which might well form sources of profit. For example, from the sap of the Scots pine and of the larch, felled in summer, barked and scraped, a substance known as "coniferin" is obtained, which yields "vanillin," the essential constituent of vanilla. Though an expensive substance to prepare, this is considerably cheaper than common vanilla, the sole source of which is the inner pulp of the pods of one or two species of orchid.

Another similar product, not as yet much developed, is the "rubber" obtained by distillation from the bark of the common birch, a black gummy "latex," which resists the action of air and acids, and which will considerably increase the durability of india-rubber or gutta-percha, even if mixed with them in only a small proportion.[1] As in the salt mines of Stassfurt it has been found that the formerly wasted bye-products, the salts of potash, are as valuable as the rock-salt, if not more so, and as in Michigan the "smoke" has proved more valuable than the charcoal, so the development of new chemical industries may render such products as this vanillin and gutta-percha more remunerative than the timber itself.

PAPER-PULP.

English oak bark, if it is to compete with hemlock extract, mimosa-bark, divi-divi, etc., must be well grown, of suitable age and size, and well harvested: charcoal for powder must be made from dogwood, willow, or alder, and for most other purposes from good-sized billets. It is only *Coniferæ* that yield turpentine or tar in any quantity, so that the forester, face to face with monetary depression, and seeking to economise, wants some other outlet for much refuse, not only from coniferous plantations, but, perhaps, still more from his mixed hardwood coppices and timber woods. This he may speedily find, it appears, in paper pulp. The immense demand for paper of all qualities—from the coarsest mill-board for roofing purposes, or for boxes, to the finest hand-made note-papers—causes a corresponding demand for every available paper-making material. Processes, such as Sinclair's, had long been in use for pulping very finely cut coniferous wood, and in the Paris Exhibition of 1880 one of the most prominent of the objects exhibited in the Norwegian Section was a *pâte de bois*, or *papier maché*, made in this way from pine wood, and worked into cardboard and various moulded panellings, etc. It has been found, moreover, that in this way the whole of a pine-tree—trunk, branches, bark, needles, and all—can be converted into paper without waste. Saplings which it would not pay to cut for firewood are now profitably worked up in this way, in the New England States, into pasteboard.[1]

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[1] *Journal of Forestry*, v. 141.

Perhaps a still more important development in this direction is the manufacture of a better class of paper pulp from the hitherto almost valueless, but quick-growing poplar. There are a great many chemical processes for manufacturing wood pulp; amongst others Dr. Mitscherlich, of Darmstadt, has invented a process by which it is not necessary to cut the wood into very fine pieces, it being boiled under pressure for some time with a solution containing lime. The wood of the slower-growing linden makes an equally valuable white paper pulp; but, by this process, oak can also be used, though yielding an inferior product that requires bleaching. One great advantage in the method is that the tannin in the oak is obtained as a bye-product, and the chemicals with it in the lye being rather an aid than a hindrance to the tanning process, it is found that hides can be perfectly tanned in it in ten days.[2] This seems to offer the cultivator of oak coppice, or the enterprising planter of poplars, a most important source of income; whilst in coniferous plantations there need be absolutely no waste.

LEAVES, SAWDUST, ETC.

In Styria young pine and fir needles, from loppings or thinnings made in spring, are dried in ovens or kilns, ground.

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[1] *Timber Trades Journal*, 1883.

[2] *Hesse Gewerbe Blatt*, 1877.

mixed with one-twenty-fifth of salt, and used with advantage as a food for cattle. Similarly, in the north of Italy, the dried leaves of the poplar have long been used as cattle food, and chemical analysis bears out their value for this purpose. When not used for fodder, however, dried leaves make an excellent litter, and analysis proves their value as manure. The following table, prepared in Bavaria, exhibits the composition of the leaves produced annually by an acre of forest under beech, pine, or spruce, as compared with that of a ton of wheat straw:[1]—

	Dry Matter. lbs.	Ash. lbs.	Potash. lbs.	Lime. lbs.	Magnesia. lbs.	Phosphoric Acid. lbs.	Sulphuric Acid. lbs.
Beech, per acre of land,	2972	165·5	1·80	73·18	10·90	9·32	3·23
Pine, ,,	2842	41·5	4·32	16·84	4·28	3·28	1·51
Spruce, ,,	2683	121·3	4·30	57·37	6·20	5·72	1·87
Wheat straw, per ton,	2240	85·2	9·80	5·20	2·20	4·60	2·41

Sawdust also forms a good litter for cows and horses; and though destitute itself of manurial value, being very absorbent of liquid manure, can, when thus soaked, be used as a valuable top-dressing.

Finally, if the forester has any waste that he cannot utilise in the tan-pit or the charcoal-retort, as paper pulp or as firewood, it is probably best to burn it, so as to avoid harbouring insect and fungus life. By so doing he will lose little of the manurial value of the refuse, and leached ashes, being rich in potash, are a valuable dressing for old grass land, orchards, market-gardens, onions, rye, and other crops. The potash might even be recovered by lixiviation of the ashes and used for many purposes.

SPECIAL CULTIVATION.

Its productiveness in timber, bark, tar, turpentine, or as paper pulp, suggests that the Scots pine might be considerably more grown than it is. There are many tracts of poor sandy soil, like the Bagshot and Lower Green Sands of the south-east of England, where the quicker-growing and perhaps more lucrative larch will not flourish, which are at present abandoned to heather. These might well be more planted with pine than they are.

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[1] *Journal of Forestry*, i. 10.

Its rapid growth and use as a paper material may in some cases recommend the planting of poplar; and certainly its value for powder-charcoal and for tanning should encourage the cultivation of alder in many a marshy tract now turned to but little account.

It hardly seems necessary that almost the whole of our supply of so valuable and hardy a timber as walnut should be imported, as it is, from Germany and Russia; and, though the return to capital is slow, there seems an equal absence of any adequate reason why our limestone hills should not yield us the several thousand tons of boxwood which we now annually import, at a constantly increasing cost, from the interior of Persia.

As a final suggestion, even a mere shingle beach will grow gorse, a plant which also seems utterly reckless of the utmost exposure to wind. Its value as food for sheep is shown by the facts that young plants of it have to be protected from them, while old ones, from constant nibbling, become of a definitely rounded outline. For cattle and horses it can be passed through a "masticator," and will certainly repay the slight trouble of its cultivation. It is better to grow even gorse than nothing. In any case, the economic policy of the forester plainly is "Waste not, want not."

XVII.

PAPER PULP FROM WOOD, STRAW, AND OTHER FIBRES IN THE PAST AND THE PRESENT.

By W. John Stonhill, *Editor of the "Paper Trade Review," London.*

"The generality of modern experimentalists seem to be wholly unacquainted with the labours of their predecessors, many of whom commenced improvement by repeating experiments which had already been made, and announce results as new which have long previously been ascertained."—Dr. Forbes Royle, *before the Society of Arts*, 1860.

"Now and again substances are proposed, and patents taken out, for new processes of making paper, by men who have never studied paper-making, which have been tried and condemned years ago."—Carl Hofmann, *author of the Manufacture of Paper*, 1873.

A beginner may hit upon an idea, then draw up a plan, dash ahead, and—fail. But if he has the ability to study and criticise the work done by others, to adopt what is good, and discard what is not, the "method" will probably be the easiest and least wasteful of his time and money. A snow-flake falls, another and another; a ball is formed, it rolls and rolls—a mountain evolves. Does not this simile illustrate the possibilities of the utilisation of wood for the manufacture of paper?

W. J. S.

1719-1800.

In 1719 Reaumur suggested, after an examination of wasps' nests, that a paper might be manufactured from wood, but this idea does not appear to have been acted upon until a much later period. Since Reaumur first suggested wood for paper pulp, the substances proposed for that purpose have been almost innumerable.

In 1734, Seba, a Flemish writer, called attention to the fact that paper might be made from sea-weed, and other savants of the period also offered many suggestions, but the practical outcome appears to have been *nil.*

In 1756 paper was made in Germany from straw.

In 1765 Jacob Christian Schaeffer of Ratisbon (Regensburg, Germany) printed an octavo work on sixty varieties of paper, produced from different plants, without the use of rags. Among the materials used were :—

Sawdust.
Willow.
Barley-straw.
Wheat-straw.
Broom-corn.
Beech.
Mulberry.
Thistle stalks.
Hop-vines.
Conferva.
Aspen.
Peat.
Cabbage-stumps.
Moss.
Burdock.
Pine.
Hemp.
Hornets' nests.
Aloes.
Mothwort.

In 1776 a volume was printed in France upon white paper made from the bark of the linden (basswood), at the end of which were some twenty specimens of paper, made from as many different kinds of vegetables. But the poor quality of the fabrics, and the cost of producing them, seem to have discouraged the inventors.

M. Leorier, at Bruges, in 1785 showed that paper could be made of a multitude of articles, and in 1786 a work was printed in London to the order of the Marquis de Villette on paper made from marsh mallow; and it is recorded that at the end of the volume were given specimens, in single leaves, of paper made of the following :—

Nettle.
Couch-grass.
Burdock.
Coltsfoot.
Hop.
Reed.
Thistle.
Wayfaring-tree.
Elm.
Oak.
Lime.
Yellow willow.
Sallow willow.
Spindle-tree.
Conferva.

Although paper was made from the above fibres by M. Leorier at Bruges a century ago, yet he failed to overcome the practical difficulties of bleaching, nor did he grasp the necessity of a regular continuous supply of fibre.

In 1794 a paper-mill was built at Fairhaven, Vermont, United States, by Matthew Lyon, at which paper "for wrapping" was manufactured from the bark of the basswood tree. This was about eighteen years after a similar experiment had been made by a French papermaker.

According to Joel Munsell, an American author, a Mr. Bidds undertook to make paper, suitable for printing purposes, from sawdust of sapwood in 1796.

The English Patent Office teems with specifications of patents, which have been taken out by inventors for making paper pulp from such things as—

Acacia.
Agave.
Aloes.
Alsinastrum.
Ammonum.
Artichoke.
Asbestos.
Asparagus.
Bagasse.
Bamboo.
Banana.
Beet.
Bean-vines.
Bran.
Brewery Refuse.
Broom.
Bulrushes.
Cactus.
Clover.
Corn-husks.
Dogs-grass.
Esparto.
Ferns.
Furze.
Grasses.
Hay.
Heather.
Hop-vines.
Horse-dung.
Jute.
Mangel-wurzel.
Mulberry.
Osier.
Plantain Cocoa.
Poplar.
Reeds.
Straw.
Sugar-cane.
Sunflower.
Turnips.
Twitch-grass.
Water-plants.
Willow.
Wood.

The above selected list, which omits all foreign inventions, shows that there are few vegetable fibres which have not been tried by British subjects for making paper pulp.

Matthias Koops was an exception to the general run of these inventors. He succeeded, in the year 1799, in manufacturing paper in quantity from straw alone. His first experiments were on a small scale. Early in 1800, however, he obtained an interest in the Neckinger Mill, Bermondsey, London, where he pushed on his experiments, and succeeded in completing various new systems of paper manufacture. At this mill he produced strong serviceable paper wholly from straw, and subsequently from wood. The capacity of the mill was 700 reams per week.

Matthias Koops, in an address to George III., in which he says that he lays "at his Majesty's feet the *first* useful paper made *from straw*, without any rags or addition, and on which these lines are printed," emphasises the fact that although Dr. Schaeffer had shown that numerous vegetables were adapted to make paper, he only proved that various fibres could probably be so mollified as to make useful paper with the addition of rags. No one however, up to that time, had been able to make it at all without rags.

Koops, apparently inspired with his success in making paper from straw, experimented upon *wood*. He was equally successful, and the samples of his paper, now before the writer, appear to be the first that were produced in Great Britain or in Europe from wood. Koops was exceedingly sanguine as well as practical concerning his invention. Here are his *own words* :—

> "It may probably be ultimately proved that paper prepared from wood will be a lighter, neater, and more durable covering for buildings of all

kinds, and it is equally true that the ingredients with which the pulp can be composed will render the substance not only incombustible, but more durable than slates, tiles, and wood in its natural state. Who can say that coachbuilders, chairmakers, and cabinetmakers will not use it for carriages, chairs, and elegant furniture? Reflect that a substance possessing such superior properties ought to be preferred,—having flexibility, hardness, and capability of being worked with infinite greater neatness and lustre than wood. Converting wood and straw may therefore be useful for a variety of purposes."

From this extract it will be seen that the ideas of Koops were solid and practical. His suggestion that wood-pulp would be used in a compressed form was at the time ridiculed. Yet what is the case to-day? In America railway car-wheels are made from it, and it is also used in England for tram-wheels. Recently a paper dome for an observatory was built and erected satisfactorily. At Cleobury-Mortimer, Shropshire, last year (1883) a mill was producing panels for coachbuilders as well as for railway purposes. Black "patent" leather was also made there for the uppers of boots. In August 1878, at Berlin, there was, at the Papermakers' Exhibition in that city, a *paper house*, tables, chairs, carpets, barrels, boats, etc. At Willesden, near London, paper of various thicknesses is now rendered waterproof, by means of cupro-ammonium, for building purposes. It is superseding the use of slates and corrugated iron for roofing.[1]

Koops states that he converted straw, wood, flax, and other fibres into paper pulp by steeping in lime water, to which sometimes was added "crystal of soda or potash." He next boiled in clean water, washed, re-boiled, pressed, and completed the manufacture of pulp in the manner then known. It is recorded in Koops' specification that the straw was cut into pieces two inches long by a chaff-cutting machine. He reduced the wood into shavings, and also cut them into lengths, by means of a chaff-cutting machine. In some instances he found it advantageous to allow the pressed material to ferment several days before reducing it to pulp.

1800-1840.

Louis Lambert in 1824 freed straw from knots by cutting off the stems, and boiled it with quicklime, potash, or soda. After washing it was exposed to the action of "hydro-sulphurs" to free it from the mucilaginous and silicious matter, then it was bleached and torn up by the rag-engines.

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[1] *Paper Trade Review*, 23d May 1884.

Papermakers on the Continent were about this time rapidly introducing the use of wood and straw. In France and Belgium, white and resinous woods, such as pine, fir, etc., were employed. M. Fremy made many experiments. He showed that wood is not made up of cells solidified by incrusting matter, as was long supposed, but of two superimposed layers —one exofibrose, short-grained, and brittle; the other is supple and fibrous, and he named it *fibrose.* He discovered that in order to make wood paper all that is necessary is to dissolve the exofibrose, and employ the remaining fibrose.

In 1828 William Cobbett in his *Treatise on Corn* wrote:— "I have not only received a parcel of *paper* made of the *husks* of *my corn*, but have sent it to have printed on it the title-page of this very book;" and yet the development of Koops' patents appears to have been very slow. Little if any trace is to be found for years after of any progress in the use of wood or straw for paper-making.

J. V. Desgrand in 1838 chopped trees deprived of bark into chips, which were put into pits and covered with lime-water. The residue was reduced to pulp by trituration.

Mr. Balmanno in 1838 boiled the bark of trees with caustic alkali, after which it was strained, reduced in the engine, and bleached.

1840-1850.

Henry Zander suggested the manufacture of paper from the dung of horses. He separated the straw from the dung, cut it very small, and washed it with water. It was then boiled and treated with caustic soda. The fibre was afterwards passed through rolls, and the pulp bleached by chlorine. It is noteworthy that only last year (1883) a similar manufacture was proposed to be started at the Wraysbury Mills, Middlesex, but the project is not yet completed.

E. Nerot in 1846 filled trenches with the bark of the osier and willow, which he covered with water. After steeping some time, the water was run off, and the stuff crushed under a millstone, then put into a lye-vat heated with steam, threshed, dried, shaken, mixed with a fifth part of coarse rags, and bleached.

About this time a number of eminent chemists devoted attention to the chemical composition of wood. Brongniart was the first to call attention to the changes undergone by wood-fibre, when subjected to the influence of alkalies; but his suggestions were not immediately put into practice.

Lagrange Bull, of Martinique, from 1840 to 1846 made paper pulp from the leaves of the banana-tree, but the limited supply prevented its continued use.

Keller, a German, invented and took out letters patent in Germany for a wood-pulp grinding-machine. Want of capital prevented him from keeping to himself or licensing his discovery, and he sold the patent to Voelter. Voelter improved certain features of the process, and in 1847 he developed the manufacture and used large quantities of wood for producing paper suitable for newspapers. This system, with slight modifications, is still in use both on the Continent and in America, and will be referred to subsequently.

Souché, the proprietor of a French paper-mill, adopted the Keller-Voelter wood-grinding process in 1849.

1852.

Jean A. Farina, of Paris, obtained in 1852 a pulp for paper from *spartum*, esparto, using both the stalks and the roots. This material at that period received great opposition alike from proprietors and workmen. The French stationer, however, soon discovered that he could use 12 lbs. demy as 14 lbs. demy rag. Munsell records that *spartum* was "known to the Romans," but omits to verify the statement, or to state if it was ever used before 1852 for paper manufacture.

In 1852 Coupier and Mellier made experiments at Maidstone, Kent, for treating sawdust and shavings by boiling in a lye of 7° to 10° (Baumé) without previously applying acids. They took 300 lbs. of lye to 100 lbs. wood, and boiled the mixture for eight hours; but as this process gave no satisfactory result, they tried Brongniart's system with nitric acid. Eighty lbs. of nitric acid were agitated for four hours with one hundred lbs. of wood, then diluted with water, and the whole boiled for two hours with steam. The acid was neutralised by adding caustic lye of 2°, and the fibre was bleached with 2 per cent. in weight of chloride of lime. These processes were not more successful than the previous ones, and Coupier and Mellier did not continue them, the cost being excessive.

Thomas Routledge (now of the Ford Paper Works, Sunderland) was the first papermaker who worked the Spanish fibre, *Alfa*, on a large scale. Pirie and Sons, of Aberdeen, followed, and soon afterwards the greater number of the leading manufacturers of England and Scotland.

1853.

George Stiff made straw paper in 1853, afterwards using lime-water to macerate the fibres, and to form half-stuff.

Moses Poole suggested the use of the *Dwarf palm*. He submitted it to combing, cutting, and passing through a metal mill, having teeth which reduce the fibres. Straw and other material were pulped in the same manner, boiled in water containing an alkaline sulphide, then treated with dilute acid, washed in ordinary water, squeezed and bleached by hypochlorite.

R. A. Brooman pulped wood by mechanical means, rasping the wood in the direction of the grain of the fibres, and utilising a stream of water to soften the grain.

In 1853 Watt and Burgess reduced chips and sawdust as finely as possible, boiled in water, and passed a stream of sulphurous acid through the mass till a partial bleaching was effected. The residue was then well washed, and placed in a solution of chlorine, where it remained until "quite white, and the fibres disintegrated." Sodw ? [illegible]

B. A. Lavender and Henry Lowe, of Baltimore, produced in 1853 samples of paper from Southern cane and from white pine shavings. They were sanguine that, with proper apparatus, paper could be made of reeds or wood as the main staple. Munsell records that by their process paper worth from 12½ to 16 cents a lb. (6¼d. to 8d.) did not cost more than 6¼ cents (3¼d.) per lb.

Thomas Jackson used flax, straw, etc., and bleached them by the direct action of chlorine gas, or by a solution of hypochlorite of lime.

1854.

T. Gray in 1854 patented another rasping process. He reduced wood to pulp by means of two serrated circular metal plates, between which the wood was placed, and exposed to a stream of water, which carried away the pulp.

J. Swindells used caustic alkali to digest the wood in the process of pulping.

A. C. Mellier took out a patent for boiling straw and other pulps in a solution of caustic soda under pressure, while being retained between perforated plates.

L. V. Helin produced pulp from straw, jute, and flax by means of steeping, draining, and rolling, and then exposing to the air and sun before treating with solutions of hypochlorite of potash.

Leon Castelain subjected straw and fibres generally to the action of solutions of lime or other alkali, or to acids; then pulped, pressed, and treated with chloride of lime and water before converting into millboard.

1855.

Martin and Martin in 1855 reduced wood to pulp, by means of a serrated cylinder, and took out a patent for the system.

T. H. H. Kelk converted wood into pulp by drying and immersing in water containing soda, potash, lime, and borax.

Cowley and Sullivan reduced pulp in a beating-engine so arranged that a grinding as well as cutting action was exerted upon the straw.

1856.

In 1856 E. E. Amyot prepared pulp from wood by stripping off the bark, cutting it into small pieces, boiling with lime, and triturating.

In the same year, Houghton, a workman in the Cone Mill, near Lydney, Gloucestershire, being engaged with the boiling of *Alfa*, wedged the boiler with pieces of *wood*, instead of iron bars, and to his great astonishment he found no trace of the wood after boiling. Without any acquaintance with chemistry or technical knowledge, Houghton thus became the inventor of the production of *lignose.*

Felix Chauchard invented a machine for dividing and separating all sorts of wood by means of a rotating cylinder having a system of combs which caught the substances submitted to them. The machine consisted of a trough for water, containing a bucket-wheel which raised the pulp, and threw it on an inclined plane leading to three rollers, where it was triturated until pulped properly. The pulp was strained through a "sieve" placed in the cap of the engine, and could then be used immediately for making common papers. By this system wood alone gave too brittle a paper, the short thick fibres hardly yielding sufficient suppleness. Proteau states that "it takes $0^{m}\cdot380$ of wood to make 100 kilog. of pulp. The motive force necessary to separate the fibres of wood is considerable. It is calculated that a 25 horse-power is required for 24 hours in order to produce 300 kilog. (661·42 lbs.), and a 44 horse-power in order to produce 750 kilog. (1653·54 lbs.) of wood-pulp."

The mixture employed about this time by Voelter at Heidenheim, Würtemburg, was as follows:—

Thin letter-paper,	20	per cent.	of poplar wood,	80	per cent.	rags.
Writing-paper,	33	,,	,,	67	,,	,,
Fine printings,	20	,,	,,	80	,,	,,
Common printings,	50	,,	pine wood,	50	,,	,,
Brown wrapper-paper,	40	,,	,,	60	,,	,,
Grey ,, ,,	50	,,	,,	50	,,	,,
Blue paper for covers,	33	,,	,,	67	,,	,,

In Belgium, in 1856, paper for newspapers was made of

60	parts	birch wood.
20	,,	kaolin.
20	,,	coarse grey rags.

The wood-pulp was added a quarter of an hour before the end of the beating process. The wood, being neither boiled nor bleached, the proportion of bleaching is diminished, as a part of the colouring matter is not destroyed by acids.

Proteau states that at this period "the introduction of unboiled and unbleached wood-pulp was considered so great an economy, that several manufacturers of paper in Belgium, Germany, and France, made additions to their mills in order specially to prepare wood-pulp."

John Cowley, C. S. Johns, and T. B. Houghton patented processes in 1856 for improvements in straw boilers, false bottoms and steam jackets being used.

C. Townsend Hook, of Snodland, Kent, first suggested the employment of alkaline sulphides, earthy sulphides, or a combination of both, with alkalies for disintegrating straw and other fibres. Hydrofluoric acid gas was sometimes used first to remove the silica.

G. P. Wheeler macerated straw with water, slaked lime, salt, sulphur, and potash at a steam heat.

1857.

E. W. Newton secured a patent in 1857 for subjecting wood in a strong cylinder to the action of steam under high pressure, for the purpose of charging its tubes as well as the spaces between them; and afterwards causing it to be suddenly projected from the cylinder, where, by the expansive force acting within and upon the tubes, they would burst open and cause the complete separation of the fibres.

1858.

The Lyman cane-fibre process was patented in America in 1858. The almost inexhaustible supply of cane, and the good qualities of its fibres, make it very desirable that it should be generally introduced.

In 1858, Coupier, Nixon, Stevens, Galloway, Alcan, and Collyer introduced improvements in the forms of boiler and in the manner of applying the alkaline solution in the formation of straw pulp. Coupier recovered the alkali after use.

1860.

In 1860 Houghton introduced an economy in working by using the spent alkaline solutions that would no longer act on flax or hemp to disintegrate wood by means of a higher temperature and increased pressure.

G. P. Wheeler in 1860 substituted chopped and devilled straw to the action of a boiling solution of soft soap and crude potash or soda. The vessel was then closed air-tight, and steam turned in until thorough maceration was effected. The residue was washed and reduced to half-stuff in the engine.

A. L. A. Herbelot charged wood chips with water by immersion, then triturated them, and bleached by chloride of lime.

E. Clemo successfully employed lime, soda, carbonate of soda, and nitric acid, for reducing wood to pulp.

Voelter introduced an improvement in his wood-grinding machine in 1860.

In 1860, raw fibrous material, with the exception of straw, was not generally used in paper-making, the waste of cotton, flax, hemp, and jute mills having undergone a process of semi-manufacture, being comprised under the generic term of Rags. The American War immediately following the repeal of the paper duty, threatening a cotton famine, papermakers gladly availed themselves of the new material, *esparto.*

1861.

Caustic soda was but little known commercially in 1861, but Weldon's new process greatly facilitated the power of production, and enabled papermakers to convert various fibres with profit into pulp.

Thomas Routledge had for some time previously been ineffectually endeavouring to introduce his process for the treatment of esparto; its popularity now grew rapidly, and led, in the year 1865, to the importation of esparto rising to upwards of 50,000 tons; in 1871 the year's imports had reached 140,000 tons, and in 1884 it was 184,682 tons, of the declared value of £1,128,143. Routledge, according to his specification of patent (1860-61), used a lye composed of from 10 to 11 per cent. of carbonate of soda, and from 60 to 70 per cent. of the quantity of lime necessary to render the soda caustic. This was dissolved in water not less than ten times its weight; the solution poured on the *esparto,* and kept boiling for some hours. The residue was then broken up, washed, and bleached.

L. A. Carteron used a similar process for straw, the lye consisting of 212 lbs. water, 72 lbs. slacked lime, and 36 lbs. crude caustic soda for every 2 cwt. Dilute sulphuric acid, gauging

1° Baumé, was used to remove the excess of alkali from raw material.

F. B. Houghton secured a patent in the same year for a cylindrical straw boiler with hemispherical ends, and a rotating shaft, on which scoops reaching nearly to the inner surface of the boiler were fixed, traversing it lengthwise. The material was by this means alternately dipped into the lye in the boiler and raised out of it.

The repeal of the paper duty in 1861 was followed in the same year by the appointment of a Committee of the House of Commons to inquire into the whole question of foreign export duties on rags and the effect on British manufactures.

The Committee's report expresses the opinion, prevalent at that time, that a foreign supply of rags, amounting to at least 15,000 tons, was essential, and that the great expense of chemically reducing straw and other fibres was such as to prevent them becoming commercial rivals to rags.

Since that time rag material has increased in quantity and diminished in price, in consequence of the export duties being abolished in some countries; and the importation of fibres and the perfection of chemical methods for their treatment have kept pace with each other.

Reference may now be made to Continental progress in the direction of utilising wood-pulp.

Payen's method for the separation of cellulose from incrusting matter in wood, by means of nitric acid, had a certain attraction. The process was however very inconvenient and costly, for with so powerful an acid the utensils used were quickly destroyed. At this period the cost of the production of wood-pulp, in spite of alluring calculations, had gradually closed all the factories. The establishment at Pontcharia had cost over £13,000 (to produce 6600 lbs. pulp daily), and more than double that in loss of capital.

It was probably the same at Bex. But this process might have had consequences still more fatal, of which neither Payen nor the papermakers who used his process seemed to be aware. In Payen's use of nitric acid there was the possibility of the formation of nitro-cellulose—identical with cotton-powder—and explosion during drying might have been the cause of terrible catastrophes.

Barré and Blondel, of Nantes, in 1861 tried Payen's process on a large scale. It attracted much attention on the Continent, and in 1864 caused the Central Department for Trade and Commerce at Stuttgart to make the experiment in their laboratories. These experiments verified the correctness of the operation, but led at the same time to the conviction that it was too costly to be used practically.

A. L. A. Herbelot in 1861 reduced wood to small chips suitable for paper-pulping, by a mechanical contrivance which need not be described.

A. L. Harivel reduced wood, at first by means of circular saws, and afterwards by the use of a common meal-mill and sifting.

1862.

In 1862 numerous advances were made in the treatment of straw. J. B. M. A. Siry made a white paper by steeping the straw in lime-water; then, after disintegration, it was bleached by watering with dilute sulphuric acid, chloride of lime solution, and pure water in succession.

Baggs and Simpson treated the straw at first with hydrofluoric acid.

Edward Lloyd and J. P. Palser employed specially constructed boilers, that of the latter being rotatory; and Vasser and Janssens used a very alkaline soap for reducing straw to pulp.

A. C. Vautier made a very white straw pulp by alternate use of chloride of lime and alkali in bleaching.

H. Bailey employed a means of mechanically reducing wood to pulp. The machine consisted of a circular grater of tempered steel, presenting on its circumference a puncture or special cutting. It was mounted on a stand like a grindstone, and made from 500 to 600 revolutions per minute.

W. W. Burdor employed fixed stones or rasps with water and a solution of sulphide of calcium, or soft soap, for the purpose of reducing wood.

C. H. Roeckner patented a rasping machine for reducing wood to half-stuff. Subsequently this inventor developed several processes for producing half-stuff, and in April last

(1884) Mr. Roeckner was engaged in working wood and other raw material into half-stuff. In a circular recently issued to the trade it was stated that 100 tons of straw would produce 40 tons of half-stuff, and that this quantity would hardly suffice to keep one mill supplied.

1863.

A. S. Lyman in 1863 employed a continuous macerating process; and B. Lambert employed mixtures of waste paper and straw or wood in making paper pulp.

1864.

Auguste Delage was the first to construct in 1864 a special machine for cutting up wood, producing at the enormous speed of 1800 turns a minute 15,400 lbs. in an hour. The principal effect of this was to avoid forming sawdust from the wood. Delage's system has never been exactly known, but it appears to have consisted of the decomposition of Chili saltpetre by sulphuric acid; the introduction of nitric acid into slices of wood, and the addition of water in boiling. Delage called his pulp "Wood Rags."

Much time and money was lost about this time on the Continent in the development of the wood-acid process.

Watt and Burgess's patent of 1853 was much improved upon in 1864. The Manayunk Mills of the American Wood Paper Company are worked by means of the improved patent. The wood, chiefly poplar, is sliced by machinery into discs of about half an inch in thickness. The discs are boiled for six hours in caustic soda solution of 12° Baumé with a pressure of 65 lbs. to the square inch. The pulp is then run into trucks, where it is drained, and after washing and filtering to remove impurities, it is decolorised with bleaching-powder solution. The pulp is either sent wet to the paper-mills, or if these are at a distance, it is rapidly dried and made up in large rolls on a cylinder paper-machine.

One of the most important features of the patent is the soda recovery. The spent alkaline solutions are evaporated, calcined to black ash, and recausticised. From 75 to 80 per cent. of the soda used is recovered in this way.

A. L. le Harival reduced wood to small shreds by running it against twenty or more circular saws, placed one-eighth of an inch apart on the same spindle. The resulting material was passed through crushing rollers, and afterwards disintegrated by millstones. The material may be boiled with lime and soda-ash, and bleached before disintegration.

E. Ledger employed a rotary engine, using cutters in such a manner that a cutter of a different pattern follows a previous one, so as to divide the substance to be operated upon into filaments of uniform breadth and thickness.

In 1864, Tait, Holbrook, and Eaton patented a system of cutting straw, etc., into short lengths, and subjecting it to the action of a burr stone. It was then passed through a winnowing machine, placed in cold water, and heated gradually, the coloured water drawn off, and a solution of caustic soda added, in the proportion of 70 gallons of the solution to 100 lbs. of the dry straw. The whole was then boiled about five hours, washed thoroughly with hot water, and boiled for about two hours with a weak solution of hydrochloric acid (1 to 30). Finally, it was bleached with solution of chloride of lime, and treated alternately with acid solution and caustic alkali.

J. Easton employed horizontal cylindrical boilers, and John Dixon, in 1864, invented an upright boiler, which seems to answer all reasonable expectations. It consists of a fixed vertical cylindrical boiler (Fig. 18), carried by flanges riveted to the shell in any desired place, and supported on solid framework or walls. The upper part projects a few feet above the floor where the straw is stored, so that it can be easily filled.

The straw is chopped into lengths of about three-quarters of an inch, cleaned, dusted, and passed through a heavy pair of iron rollers, to open out the tubes and knots, after which it is transferred to the boiler A. This is partially filled with a solution of caustic soda, in the proportion of 60 gallons to each 100 lbs. of straw. The manhole cover (*b*) and diaphragm cover (*c*) are removed, and the straw and caustic solution alternately introduced; the latter is drawn from a tank by a rotary pump (*d*), and when the boiler is filled the supply is cut off. The caustic alkali percolates through the straw, collects at the bottom of the boiler, and is drawn therefrom by the rotary pump through the pipes (*f*, *g*), returning through the heated coil (*h*), made of extra heavy 2-inch wrought-iron pipe, placed in a brick furnace, to the upper part of the boiler, to be again passed through the straw. The straw is removed when boiled by withdrawing the slide valve (*i*) by means of an exterior handle.

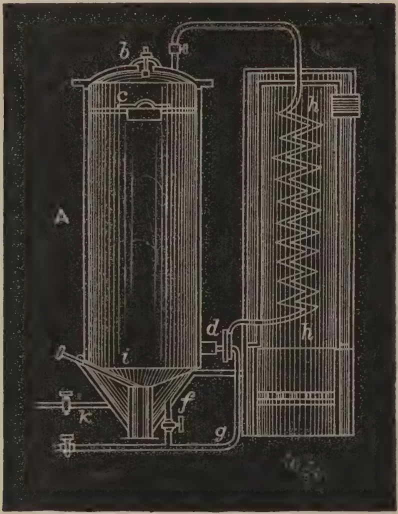

FIG. 18.

The maker recommends 60 lbs. over-pressure for boiling wood with alkali. He sets two or more boilers close together, and fills one of them with wood, chopped into pieces of 1 inch in thickness. This wood is boiled with a solution of caustic soda, of from 9° to 10° Baumé, which, when done with, is used for the digestion of straw in the second boiler. The best method of working seems to be that adopted at the Ashland Mills, near Philadelphia. There a caustic solution is prepared from 1 lb. of soda-ash of 48 per cent. for every pound of paper obtained from wood, or, as a cord of wood furnishes from 800 to 1000 lbs. of white paper, from 1000 lbs. of soda-ash for every cord of wood. When the solution has acted on the wood, it is blown through the pipe (*k*) into a receiver, situated on the upper floor, and after having been heated by the direct introduction of steam, a portion of it is drawn off and mixed with fresh liquor prepared for straw. Unless the liquor which has previously been used on wood is well heated and mixed with a fresh solution, the straw, which is subsequently treated with it, will furnish poor pulp.

The waste liquor from one boiler of wood is, by this method, divided between two or three of straw, and 25 lbs. of white paper from wood, and 75 lbs. from straw, or altogether 100 lbs. of white paper are thus obtained with the use of little more than 50 lbs. of soda-ash of 48 per cent. by this process of boiling. In several other American mills straw alone (no wood) is digested in Dixon boilers, and the caustic liquor used is then only of a strength indicated by 3¼ degrees of Baumé's hydrometer.

1865.

A patent was taken out in 1865 for a wood-pulping apparatus provided with an iron rake to take hold of the largest splinters. A projecting bar and sieve served for sorting the fibres.

In 1865, Orioli, Fredet, and Matussiere patented in France a system of treating wood with *aqua regia*. The invention is based on the discovery that *aqua regia*, a mixture of 5 to 40 per cent. of nitric acid with 95 to 60 per cent. of hydrochloric acid, destroys all ligneous or intercellular matter, without attacking the fibre or cellulose. After the wood or straw has been soaked in this acid, the excess of liquid is drawn off, and the solid part ground under vertically revolving millstones. The brownish-coloured pulp thus obtained is washed and bleached as usual. The difficulties which are encountered in any large use of strong acids are, however, insurmountable. They destroy all metal vessels. All the pipes must be of glass, and any escape of gases would be unendurable. The formation of the explosive nitro-cellulose is another possible danger.

Cornes and Simpson patented a machine for cutting straw, etc., to assist in preparing fibrous plants, etc., for pulping.

A. Meucci treated straw and wood with the substances produced by the action of *aqua regia* upon carbonate of lime and iron, or their equivalents, and then subjected the vegetable material to the action of caustic alkali.

During 1865, Palser, in conjunction with his partner, Howland, patented a rotatory pulp digester, which met with favour in America. R. H. Collyer took out a patent for reducing straw to pulp, and E. H. C. Monckton adopted a similar process. Considerable attention was given to Routledge and Richardson's method of treating esparto and other fibres, for which a patent was secured. S. Trotman heated straw with solution of an alkaline carbonate by means of steam, and Nixon patented a rotary pulp-boiler, suited for using with wood. It differed from Palser's by being composed of concentric cylinders, so arranged that the hot air from the furnace traversed the apparatus twice, and so insured more rapid and thorough heating of the contents. A. G. Ermen treated straw with hydrochloric acid until no colouring matter remained neutralised with lime-water, and then boiled with caustic soda for a short time, and bleached as usual.

Eckel, Schuyler, and Gillies boiled straw in a potash and salt solution, and bleached in chloride of lime and sulphuric acid.

1866.

T. Kingsland, an American papermaker, invented in 1856 a new pulp-grinding machine. It was hardly known until 1866, when several were at work in his mill at Franklin, New Jersey. The machine has a closed reservoir, with serrated circular sides, which form the opposing surfaces to the toothed grinding disc. The wood or other stock to be ground is fed in with a current of water at one pipe, and discharged at another, the pressure being obtained by a hydrostatic column, and the rate of passage determined by means of the adjustible discharge aperture. If the fibre be tender and easily reduced, it will flow freely through the grinder, and occupy little more space on the feed-side than on the discharge-side of the disc; but if the fibre be tough and slowly reduced, it will accumulate on the feed-side, crowd the disc back, and retard its escape. The stronger fibre is through this action subjected to severer grinding than the weaker one, as it should be.

Jones, Farquharson, and Colton bleached wood and straw in a hollow cylinder, into which the bleaching liquor was forced by pumping until a pressure of 120 lbs. to the square inch was obtained.

E. Nelson introduced some modifications in making wood pulp.

F. Burghardt, of Curtisville Mills, Massachusetts, claimed to save half the power used by Voelter's stones, already referred to, and to produce a more uniform pulp by means of a narrow iron cylinder revolving vertically, the sides of which are covered with a paste which contains a large quantity of flour of emery, becomes hard in a short time, and resists the influence of water.

B. C. Tilghmann treated wood, straw, etc., with a solution of sulphurous acid heated in a close vessel under a pressure sufficient to retain the acid gas until the intercellular or cementing matter existing between the fibres was dissolved. The temperature ranged from 127° to 138° C. To obtain a good result the treatment may have to be repeated several times. This patent subsequently formed the basis of much litigation on the Continent, especially in 1883-84.

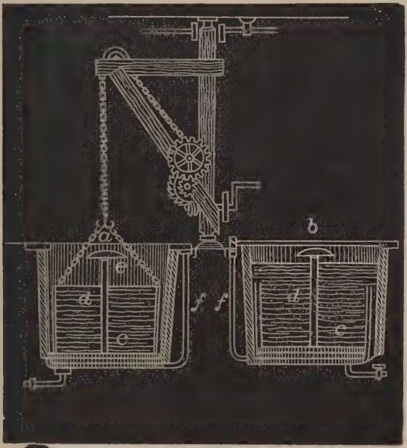

FIG. 19.

D. A. Fyffe patented a process by which he utilised sawdust ground fine by the use of millstones, for making paper pulp.

About this time an apparatus was introduced in France for boiling paper stock. The boiling tubs *a* and *b* (Fig. 19) have perforated false bottoms *c c* carrying upright pipes *d d* surmounted by bonnets *e e*; steam is admitted through the pipes *f f*, and distributed throughout the mass by means of apertures in the perforated false bottom. The tubs are one-third or one-fourth filled with a solution of soda. The liquid is boiled by steam rising through the pipes *f f*, and deflected by the under surface of the bonnet; the material is then gradually thrown in and distributed as uniformly as possible. After boiling, the mass is hoisted out of the tub by chains, which are hooked to a frame connected with the false bottom, and attached to the lifting chain of the crane. The tubs have covers of metal or wood to prevent escape of heat or steam. The spent liquid is drawn off by the pipes below.

In speaking of Payen's process (1861) the mill at Bex was referred to. It belonged to Bachet and Machard, and they worked it in 1866. The process adopted consisted in obtaining alkali by distillation, 35 feet of wood giving 45 gallons of alkaline liquor. The experiment with 15,444 lbs. of wood reduced into slices gave the following results :—

Wood sawdust, ...	2436 lbs.
Bark, ...	962 „
Loss and drying, ...	11,580 „
Serviceable wood, ...	474 „

The treatment of this quantity of wood cost on an average 13s. 1½d. After the distillation there was used for the boiling 1232 lbs. of hydrochloric acid, and 1540 lbs. of coal. The labour cost 14s. 6d. The operation lasted eleven hours. The slices that were brown and brittle were washed and ground, an operation that required five and a half hours, and cost 2s. 6d. Each charge of pulp was diluted, the process occupying two hours, and costing 2s. 1d. for labour. Each charge (418 lbs. of pulp) gave 374 lbs. of dry paper, 12 lbs. of clippings, and 56 lbs. loss. Consequently the brown pulp of wood fibre cost for the wood 5s., peeling and sawing, 1s. 1d., hydrochloric acid, 2s. 4d., coal, 1s. 2½d., labour in boiling, 1s. 7½d., ditto wetting, 1s. 1d., ditto pulp, 1s. 9d.—Total 14s. 5d. 220 lbs. weight of pulp cost 7s. 7d., but this sum could be reduced, when the process was carried on on a large scale, by about 1s. 6d. To this must be added the cost of bleach as follows :—

Sulphuric acid,	£0	19	2½
Manganese,	0	9	0
Chlorides,	0	11	7
Lime,	0	0	3½
Coal,	0	4	5
Labour,	0	10	0
	£2	14	6

Therefore 176 lbs. of white and dry pulp, giving 220 lbs. in the product, cost £3, 13s. 4d.

Fletcher, of Dambridgeport, brought out a process by which 2000 lbs. of slices or blocks of wood were boiled at a high pressure in a serpentine boiler with 5 lbs. of quicklime and 8000 gallons water. This produced a boiled pulp which did not blacken. In order to make the pulp bleach well soda-lye was added. It was made by using for 100 lbs. of wood 2 lbs. of carbonate of soda and 1 lb. of quicklime, and six hours' boiling were required to decompose the wood.

Molemann and Laubuhr recommended the use of sulphate of potash or sulphate of magnesia in practising the alkaline method.

John Priestley, an American papermaker, found, after repeated experiments on a large scale, that sulphite of soda, besides being much cheaper, proved to be more efficient than caustic soda in the manufacture of wood-pulp.

The first to treat the subject of the cost of paper-making from wood on an economic basis was Sinclair, who however was thought at the time to overlook the loss involved in materials. Sinclair's calculation possesses historical interest from the fact that it was the first attempt to calculate definitely the expense of the materials used. He considers that 100 parts of wood are thus composed :—

Wood fibre,	62¼
Bark,	10¼
Knots,	2¼
Mineral substances,	1¼
Water,	24

Further calculation shows that 62¼ parts of wood fibre consist of :—

Liquor,	32¼
Incrusting matter,	30

Thus from 100 parts of wood only 30 parts of wood fibre can be obtained; 1000 parts of fibre will therefore require 3333 parts of raw wood. Mr. Sinclair estimated that $16\frac{2}{3}$ parts of sodium hydrate would suffice for making 100 parts of wood fibre. This would decompose 50 parts of incrusting matter and produce 50 parts of pure wood pulp.

The following is the estimated cost of fitting up and working a wood-pulp mill, according to Sinclair's calculation at that period:—

Capital and Plant.

4 boilers, holding 935 gallons,				£1290	0	0
1 wood-cutter, requiring 8 to 9 horse-power,				90	0	0
Apparatus for recovery of soda,				600	0	0
Fitting and masonry,				120	0	0
				£2100	0	0
Land and building,	£1200	0	0			
Engine, 12 horse-power,	540	0	0			
Various fittings,	510	0	0			
Sundry expenses,	100	0	0			
Working capital,	900	0	0			
				3250	0	0
				£5350	0	0

Working Expenses.

45,000 cwts. wood at 1s. 6d.,	3275	0	0
12 workmen—wages,	510	0	0
12,000 cwts. hydrate soda, at 12s.,	7200	0	0
20,000 cwts. coal, at 1s.,	1000	0	0
Repairs,	325	0	0
Office and trade expenses,	420	0	0
Extra expenses,	42	10	0
Interest, 5 per cent. on £5350,	267	10	0
Depreciation on £3600 at 10 per cent.,	360	0	0
	£13,400	0	0
Recovery of soda, 70 per cent., 8400 cwts. at 12s.,	5400	0	0
Net,	£8000	0	0
Sale of 15,000 cwts. lignose, at 28s.,	21,000	0	0
Net annual profit,	£13,000	0	0

This calculation excited much interest and speculation, and induced many outsiders to embark in the manufacture of what they did not understand. As might be expected, the result was not generally satisfactory.

In Germany, Sweden, and Norway, the impulse thus given to the manufacture of wood pulp produced substantial results, which may be accounted for by the favourable conditions existing in regard to vast forests, abundant water-power, and cheap labour. America, too, slightly benefited by what, in their peculiar phraseology, they would call a "boom."

About this time English and Scottish papermakers' engineers extended their business, by introducing on the Continent apparatus for the reduction of wood to pulp—a connection which several leading firms have maintained up to the present time. Many of these reducing projects were undoubtedly immature, and modifications became necessary. Sinclair's calculation was shown to omit certain considerations which would have modified his result, but he ultimately succeeded in recovering alkali as high as eighty-five per cent., and thus effected an important economy in manufacture.

1869.

In 1869 Tessie de Mothey and Maréchal of Metz introduced a process which was unsuccessful.

A period of transition followed, during which chemistry was regarded with more attention than had previously been the case.

W. Deininger, of Potsdam, after many fruitless attempts, devised a method of utilising straw, rushes, nettles, and broom. He then directed his attention towards the treatment of wood. The wood was boiled with soda, which carried off, at four atmospheres, in 18 per cent. of the soda, the resin, colouring matter, albumen, pectine, etc. The black liquor was collected, and the fibre treated with carbonic acid, and finally washed. The inventor, however, did not issue any calculation of the precise cost of the pulp thus obtained, and the system therefore did not meet with the encouragement he anticipated.

It may be mentioned that the first wood-pulp factories established in Germany, Austria, Sweden, Norway, and Denmark, utilised either the system of Houghton and Lee, or that of Sinclair and Nichols. After a year's experience, however, it was found that pulp could not be profitably produced by these methods, in regard either to quality or price. Hence the methods were abandoned.

Hahn, the German inventor of Koenigstein, visited England, and was induced to adopt spherical and rotary boilers, heating them to 388° Fah. (at a pressure of 9½ atmospheres). These were built to contain 2300 lbs. of wood, and an oven was arranged for the purpose of concentrating the lye and recovering the soda, but subsequently he replaced it with a better system, of continental origin.

About this time Max Dresel visited various English and Scottish mills, and was led to believe that the English process might be improved. Hence he constructed a cylindrical boiler forty feet long and four feet in diameter, in which 7000 lbs. of wood could be treated at a time. Wood was allowed to boil with an alkaline solution for from four to six hours *without rotation.* The lye was afterwards conducted to an ordinary oven, where it was calcined and formed raw soda, from which 50 to 60 per cent. of the original sodium hydrate was recovered.

Fry introduced a new method of reducing wood to pulp at Brussels. The wood was cut diagonally by means of an apparatus consisting of two rows of knives. The cut wood was placed in a boiler and boiled for six or seven hours at 298° Fah. It was afterwards strongly pressed to get rid of the water. This produced a long woody fibre, similar to hemp, which could be used for cordage, etc. To utilise the water, it was conducted through a curved pipe, and passed to the still, to separate the liquid from the solid matter. The liquid contained acetic acid and wood-spirit. The solid parts were composed of resin and other materials in small quantities, which were subjected to dry distillation and then refined. By washing the residue the resin formed a crystalline deposit. The turpentine, wood-spirit, vinegar, and wood fibre were extracted, and the wood filaments boiled in caustic lye. They were afterwards carefully washed, ground, and bleached.

Robbins and Southmayd's apparatus for treating *bamboo* and similar fibres consists of a retort, boiler, and digester. Heat is applied to the retort and boiler, and vapour from oleaginous substances in the former, and steam from the latter, are driven into the digester in which the fibre is placed.

1870-1880.

Albert Ungerer, at Summering, in 1860, devoted himself to the manufacture of wood pulp, and, at the suggestion of Henry Voelter, devised a process for bleaching economically on a large scale. After repeated attempts, most of which were failures, he conceived the idea of decomposing wood chemically into its cellulose. In 1872 he established at Wartenstine a wood-pulp factory conducted on his new system, but the buildings were burnt down shortly after their erection. The success of the new system had not been clearly demonstrated, and as Ungerer was not able to obtain the necessary funds for the opening of other works, some years elapsed before his system got into active operation. In this process the wood, when cut up, was treated in a range of vertical cylindrical boilers with a solution of caustic soda, in such a manner that the lye passed from one boiler into the other, under the necessary conditions of temperature amd pressure; the latter did not exceed six atmospheres. The lye was finally removed and concentrated for the recovery of the soda, in a special apparatus devised by the inventor. The produce was removed from the boilers at regular intervals, and fresh charges of rough wood inserted. Ungerer thus described the rationale of his method:—The incrusting and inter-cellular matters differ in their solubility, although each kind is similarly acted upon by the lye. Whilst some parts are soluble in pure water, or a very weak lye at 212° Fah., others dissolve only at 280° or 290° in a stronger lye, and some only at much higher temperatures. He only used the greenest wood, as that contained the most soluble combinations. It was treated first with a very dilute lye, and the whole of the soda in the solution was exhausted. For substances containing a larger quantity of incrusting matters, a stronger lye was required and higher temperature. By this process the alkali was entirely used up, the black liquor being rendered neutral, if not slightly acid, a point which is not obtainable in other processes.

Various forms of machines were used for grinding wooden blocks into pulp. In one form, much employed in America, the blocks are pressed against a grindstone by a spring or weighted lever. The ground pulp is received in sieves, which are metal plates, perforated by elongated meshes, to separate the pulp according to the diameter of the fibres, and arranged to deliver the different qualities into different receptacles.

Another apparatus for grating wood to form paper pulp is represented in the annexed woodcut (Fig. 20). The cylinder *A* has a surface adopted for grating, rasping, or filing, and is rotated by a friction wheel *N*, at the same time that a traversing motion is imparted by a worm-wheel on the shaft *G*, and the worm *E*, on the shaft *F*, to a hopper, which contains the wood. *L* is a cleaning cylinder covered with card leather, and running in contact, or nearly so, with the cylinder *A* to remove the pulverised wood.

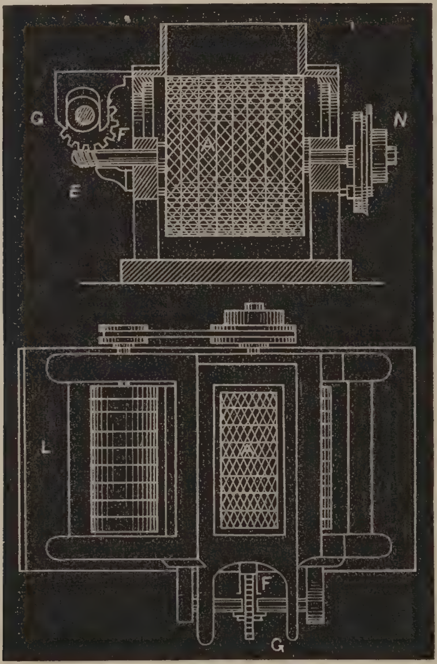

FIG. 20.

William Adamson of Philadelphia patented the use of hydro-carbons in the production of paper stock from *wood*, in 1871. He recommends treatment with *benzine*, in closed vessels, with 5 to 10 lbs. pressure, according to the quality of the wood. His digester consists of an upright cylinder, wherein the wood-shavings or other materials are contained, between two horizontal perforated diaphragms. The mass is heated beneath the lower diaphragm by a coil, through which steam circulates. The vapours, which escape through a pipe on the top of the digester, are condensed by passing through a coil immersed in a cistern of cold water, and return to the lower part of the digester. The portion of the benzine which has remained liquid is saturated with the extracted matters, and can be drawn off through a faucet at the bottom. *Straw* and other vegetable substances are rapidly disintegrated by this process, and sawdust can also be treated by it.

A system of boiling wood at Maine is mentioned by Hofman in 1872. A strong cold solution of caustic soda is forced under high pressure into a boiler loaded with chips of wood, with which it is allowed to be in contact only during a very short time. The solution is soon drawn off, and the wood emptied into a boiler, where it is subjected to the influence of high temperature, produced by steam circulating in the outside jacket. A good-looking *brown* paper is produced by this process.

Thomas Routledge, now of the Ford Works, Sunderland, first drew the attention of British papermakers to bamboo as a raw material. At present it is not used for paper-making in England; but in the East the manufacture is continued, although on a limited scale.

In Japan a strong paper is obtained from the bark of the *Morus papyrifera*, a mulberry. Samples of this paper appeared in the *British and Colonial Printer and Stationer*, London, December 1882, and also in a subsequent issue. As, however, the bark of the mulberry, when stripped and baled, cannot be bought in England under £30 per ton, its use must be very restricted in this country. One or two British papermakers mix a small quantity of it with rags for the finest plate papers.

The *Paper Trade Journal* of New York, in 1875 or 1876, described the then almost new process of converting sugar-cane into paper pulp, and stated that in its early stages a considerable amount of money had been lost in the enterprise. The process consists of exposing the cane to a jet of steam to get rid of all the saccharine juice, then passing it through an alkaline bath and washing with dilute acid. The material thus becomes properly fitted for treatment by the papermaker, who bleaches it with chlorine, and by the usual processes prepares it for the rolls. It is said that fibre thus prepared needs less chlorine than is generally required. The process is valuable, since it makes so large a bye-product as the refuse cane of sugar-mills available in the industrial arts. This method, according to L. M. Aug. Puiget, a French engineer, writing to the *Technologiste* newspaper, is a modification or adaptation without recognition of the system of MM. Meritens and Kresser, which was patented in 1875.

It appears that although the extraction of cellulose from "refuse" cane promised to be of considerable value, it has hardly come up to expectation as yet. An eminent firm of papermakers' engineers in Edinburgh have very recently received an order to fit up a paper-pulp mill in Demerara, to produce half-stuff from "bagasse," or refuse cane.

1881-1884.

There is still a probability of the British sugar-growing possessions being of value as a field for the supply of paper stock. The fact that in 1884 capital is forthcoming to reopen the industry in Demerara—it failed in Jamaica—should remind the paper trade of the publicly expressed opinions of Thomas Routledge. In his early career, papermakers were just as dubious concerning the possibilities of esparto, yet its advantages are admitted on all sides, and but for its very low price in 1883 many mills would never have been able to tide over the almost ruinous sudden advance in the cost of *Bleach*. Fortunately esparto fell about £2 per ton (quoting from Ide and Christie's Circular), equalling £4 per ton of paper produced, whereas the increased cost of bleach per ton of paper was a shade less, even at the highest "scare" price. This fact alone should induce papermakers to be less reluctant to experiment in any direction where there is a large and regular supply of any neglected raw material containing a good fibre.

Without exception, every journal published in the interests of the paper trade, in Europe and America, from 1880 to 1883, has admitted that it cannot be denied, even by the most rigid of pessimists, that *wood is taking a large part in the paper industry;* and furthermore, it is admitted that the *partial* success even, of any of the processes extant, is sure to cause a most important rearrangement in price of most of the materials now in use for papermaking. Inventors have been busy, and several chemical processes are under the consideration of the trade.

The *Ekman* process, excepting the Tilghmann patent, is the first in the field for British papermakers. The proprietors of this process have tested their system at a small mill in Ilford, near London. The wholesale stationers are familiar with very good writing and printing papers, resembling in appearance rag papers, at nearly half their price, being sold at 4½d. per pound.

The Ekman Company have recently purchased a site for a new mill of large dimensions, at Northfleet, on the Thames. The requisite machinery was ordered recently from a well-known Edinburgh firm of engineers. It is therefore reasonable to deduce from these facts that the elements of a complete and lasting victory over the difficulties of utilising wood for paper pulp has been gained.

Considering the recently obtained results, it is surprising that wood has so long been left in abeyance as a substitute for rags.

During the past few years many "writing" mills have overcome their prejudices, and use a certain quantity of wood pulp in many of their moderate grades of writing and printing paper. The trade journals state that paper pulp can be produced from wood by acid processes at from £10 to £12 per ton.

Carl Daniel Ekman patented in 1881 an improved wood-acid process in connection with the system already referred to as at work at the Ilford Mills, near London. He states that the wood is boiled under pressure, with a solution containing sulphurous acid and magnesia in certain proportions, and under special conditions. He also introduces a system of blowing off gas and steam during the process of boiling. Potash or soda may be employed for the purpose, but Ekman prefers to use magnesia, as being more economical, and having chemical properties which render it peculiarly suitable. The following details are from the specification of patent, dated 13th July 1881:—

It will be convenient to describe the process as applied to Swedish white fir of good quality and fine grain, previously freed from bark and knots, and cut into pieces of suitable form and size—say of from one-half to three-quarters of an inch long—and subsequently crushed between rollers, so as to render the wood easily permeable by the liquid solution, in order to produce fibre of the best quality for paper-making. But the mode of preparation may be varied.

White fir and trees of the same order are especially suitable, as they give long and strong fibre, very clean, and similar in its properties to that of flax. This kind of wood is comparatively cheap, and abundant in many countries. When a superior quality of pulp has to be produced, all exceptionally resinous and hard pieces of wood, as well as those damaged by rot, are to be thrown out. Wood in small pieces, thus prepared, and duly sorted, is put into a jacketed boiler, mounted on trunnions, lined with *lead* (or other suitable material), and completely covered with the solution.

The proportion between the sulphurous acid and the magnesia found to be most advantageous is—two equivalents of sulphurous acid to one of magnesia; or, approximately, that of bi-sulphite of magnesia. The strength is 1·4 per cent. of magnesia, and 4·4 per cent. of sulphurous acid.

The wood is prevented from rising above the liquid during boiling by a perforated leaden plate. A cover to the boiler is bolted on, and made tight. Steam from 10 lbs. to 15 lbs. pressure per square inch is then passed gradually into the jacket of the boiler. When the pressure in the boiler—not the jacket—begins to exceed 5 lbs. to the square inch, a valve is opened, so that a small quantity of gas and steam escapes. The pressure of steam in the jacket is gradually increased as the steam pressure is seen to rise in the boiler itself. The pressure in the jacket should not at any time exceed that in the boiler by more than 30 lbs. per square inch. After two hours the pressure in the inner boiler is 10 lbs., and this is increased 20 lbs. per hour for the two following hours; next hour 15 lbs., and in each of the two following hours 10 lbs. At 85 lbs. or 90 lbs. pressure per square inch the boiling is continued from one to three hours, the completion of the process being indicated by the smell. The cover is then removed, the boiler turned on its trunnions, and the fibre strained, washed, and beaten. The liquor may be treated to obtain a substitute for dextrine and other useful products, and for the recovery of the chemicals.

By modifying the above process other woods besides the white fir can be used. Very resinous wood however is only useful for coarse papers.

On February 7, 1882, Ekman patented the adaptation of his process to the treatment of hemp, flax, jute, and straw, in which both the quantity of chemicals and the pressure are considerably reduced.

James Anthony Graham, in his specification of patent, dated November 10, 1882, refers to the Tilghmann Patents (No. 2924, dated November 9, 1866, and No. 385 of February 11, 1867), already commented upon in this Essay. Graham states that in carrying out this bi-sulphite process there is a *constant loss of sulphurous acid* gas going on, and consequently a continual weakening of the solution employed. In order to avoid this, he employs the mono-sulphite of potash, soda, magnesia, lime, or other suitable base and water, or a solution of sulphurous acid, so as to form in the boiler a solution containing an excess of sulphurous acid. After the hydrocarbons, air, and gases natural to the fibrous substances have been driven out by the heat, and allowed to escape through a valve provided in the boiler, he injects sulphurous acid and water. The valve is then *closed during the remainder of the operation.* Thus little or no sulphurous acid is lost during the time the gases are being driven out of the fibrous materials.

The interior of the special boiler, and all parts with which the sulphurous acid come in contact are *lined with lead*, so as to resist its action. This lead lining is coated on to the boiler in a special manner, and upon examination appears to be homogenous with it.

It is noteworthy that Graham acknowledges the patents of

C. D. Ekman, already described in this paper, and does not claim as his invention "anything claimed by Ekman in the specifications of his patents."

On the Androscoggin river at Gilbertville, Maine, U.S.A., a wood-pulp mill was built in 1881. It is occupied by the Denison Paper Manufacturing Co., and now employs seventy men. It runs night and day, and manufactures every month 350 cords of poplar and spruce into pulp, consuming in the work 500 cords of fuel, 45 casks of soda ash, valued at £109 per cask, and nine car-loads of lime, 24,000 lbs. to the car. It produces 1,000,000 lbs. of wet fibre, valued at £3400, monthly.

In February 1883 it was stated in the newspapers that the cost by the Francke wood-acid process of wood and chemical plant for the production of 30 tons weekly was £8000, whilst it may be added that upon the only Ekman process established in England (Ilford Mills) a sum of £13,000 to £14,000 has been expended in order to produce 20 tons of wood paper per week. The results have, however, been so very satisfactory that Messrs. Thompson, Bonar, and Co., the proprietors, have ordered two large new paper machines of Messrs. George and William Bertram, Edinburgh, and it is expected that the weekly output at the new mill will exceed 70 tons. This will be the most satisfactory example of the value of Ekman's process.

From one of the trade journals, it would seem that in the promotion of the various new schemes it is urged that the English manufacturers can make paper equal to that of esparto at a saving in cost of raw material of about £10 per ton. Wood, it is stated, sufficient to make one ton of paper can be obtained in unlimited quantities at a cost of £5, delivered at any port in the United Kingdom. This figure is apparently based upon the present price of those parts of the tree—"the tops and big branches," according to one authority—which cannot be utilised for constructive purposes. This wood contains the largest number of knots and pithy cores, and it is absolutely necessary to free the pulp of these as well as from any portion of bark.

Ide and Christie wrote to the *Paper Trade Review* in 1883 that, according to the French Government surveys, esparto was not so limited in supply as certain members of the paper trade had stated. The province of Oran alone yields 600,000 tons per annum. They further stated that if the demand for esparto diminished very much its price would fall to such an extent that it would approximate to that of wood. The lowest price at which esparto is likely to be shipped to England, even if obtained for nothing, is £4, 7s. per ton.

Swiss wood-pulp exports for 1883 were valued at over £20,000.

On the 11th October 1883, Moritz Behrend, the lessee of Prince Bismarck's mill at Coeslin, disputed the validity of the Mitscherlich wood-acid process for converting wood into pulp. He relied chiefly upon the Tilghmann British patent No. 2924, dated 9th November 1866, referred to previously. After a very long trial and examination of technical experts, the German Board of Patents concluded that the Mitscherlich process did not differ from that of Tilghmann sufficiently to entitle it to protection. The costs of the trial were borne by the defendant, the decision being held over for six weeks. Since that time no change of verdict has been recorded, so that it is clear that the Tilghmann patent annuls that of the more recent claim for protection. This is important to British papermakers, now that the duration of the former has lapsed.

According to the *Papier Zeitung*, one large continental mill has taken up the Graham wood-acid process, principally for the manufacture of papers to compete in Great Britain with our tub-sized writings.

J. A. London, of Newcastle, submitted to the trade samples of *brown* paper made with from 25 per cent. to 50 per cent. of peat. He stated that no extra machinery is required for the adoption of this fibre, as it is fully prepared before being delivered into the papermaker's hands. The trade, however, did not take kindly to the proposed system, and as a company has recently been formed to utilise his process, judgment must be deferred.

The new wood-acid or bi-sulphite processes made no progress whatever in America during 1883. The first record of any successful manufacture is given in the *Paper Trade Journal* of New York in its issue of May 1884. On this date the editor states that he had received "samples of spruce and poplar fibre, and paper made therefrom at the first mill in this country (U.S.A.) to adopt a bi-sulphite process of reduction for wood. The mill was constructed specially for this purpose, and has successfully started up. The results seem to be such as *will effect a change in paper-making* in this country (U.S.A.) if the cost of production is not so considerable as to operate adversely; but we have been informed that the economical features of this production are sufficiently assured."

The patent of Blitz for cellulose consists in taking two parts of bi-sulphite of soda, one part of caustic soda, and one gramme of vanadate of ammonia in four grammes of hydrochloric acid to each six kilos of the bi-sulphite. The wood, after being cut up by the ordinary process, is submitted to the action of the above mixture under a pressure of three or four atmospheres, for from four to eight hours, and the pulp is then ground. It possesses some of the qualities of rag pulp, and looks much like it.

As an example of the rapidity with which work can be done, the *Southern Trade Gazette* of Kentucky, in April 1884, recorded that at a wood-pulp mill at Augusta, Ga., a tree was cut down in the forest at six o'clock A.M., was made into pulp, and then into paper at six o'clock in the evening, and distributed among the people as a newspaper by six o'clock the next morning. From a tree in the forest to a printed newspaper, being read by thousands, in the brief round of twenty-four hours!

We have now traced up the history of paper-making from material other than rags from the earliest time to the present day. Many of the processes alluded to are now obsolete, others may have in them the germs of further advances.

The economic aspect of the subject has not been strongly dwelt upon, but this must be considered when the question of the future staple paper material comes up. It is evident that in Great Britain there is not a timber supply to permit of favourable competition with foreigners in wood paper. Will the advantages of the Ekman process meet the difficulty? The Continental mills, situated close to extensive forests, and provided with the finest machinery of extra size and power, built in Great Britain, and kept running day and night, and all the week through, without cessation, are able to produce paper from *mechanical* wood-pulp far more rapidly and cheaply than can be done in this country, with the heavy freights on the raw material and the restricted hours of labour.

If the British paper trade is not to suffer severely, some authorities assert that it will be necessary to fall back upon some raw material of home growth, which can be supplied cheaply and in quantity. Straw, and straw only, meets the requirements of the case. By Leunig's new chemical process for treating straw, the details of which are not made public, although its efficacy is vouched for by satisfactory authority, paper can be produced from straw only hardly to be distinguished from that manufactured from cotton rags; and it can be made for about £12 a ton, not taking into account the saving produced by recovery of the chemicals employed. This process is now being adopted at a large Kentish mill, and, if the published cost of manufacture is correct, it cannot be doubted that the system must introduce great and most beneficial changes in the British paper trade.

XVIII.

THE PRODUCTION OF WOOD-PULP.

By G. F. Green, *London.*

The wood-pulp industry may be said to have commenced in the year 1846, but its development during the first thirty years was decidedly slow. Since 1876, however, the production of this material has increased rapidly. Considered as a branch of Forestry, the importance of this industry is not very great. The total imports of wood into the United Kingdom are stated to be 290,000,000 cubic feet annually, which is computed to be equal to about 5,000,000 tons. Against this the imports of wood-pulp of all kinds probably do not exceed 50,000 tons, or one per cent. of the whole; but if we compare the consumption of wood-pulp with that of esparto, which is about 190,000 tons annually, the importance of this product to the papermaker becomes apparent.

In a practical essay it is not necessary to do more than glance at the pre-industrial period, when wood-fibre was known only to the chemist. Cellulose was made in the laboratory in 1840, but it was not manufactured commercially till 1852. Ground wood was first used for paper-making about the year 1846, when it was manufactured by Keller under a patent taken out in Saxony in the previous year. Since that date many improvements have been made in the machinery and methods used in grinding, the main object being to produce a longer and finer fibre, but no essential change has been introduced in principle. The fibres of the wood are torn away by mechanical pressure against a revolving grindstone in contact with water. No chemical treatment of the wood is necessary, the only requirements of this industry being cheap wood, abundant water-power, and suitable machinery.

The preparation of chemical fibre (*i.e.* pure cellulose) is a less simple matter, and has given rise to two distinct processes, each of which is the subject of numerous patents. Amongst these may be mentioned—

Watts', . . .	19 Aug. 1853	Soda process.
Houghton's, . .	17 Feb. 1857	,,
Sinclair's, ...	. Nov. 1869	,,
B. Brown's, . . .	1874	,,
Tilghmann's, . .	1866 and 1867	Acid process.
Mitscherlich's, . . .	1874	,,
Vantravers and L'Heureux',	14 Jan. 1874	,,
Lioud's, ...	1877	,,
Ekman's, ...	1881	,,
Francke's, ...	1881	,,
Graham's, ...	1883	,,
Archbold's, ...	1883	,,

besides some German and French patents, which have not attracted much attention in this country, and do not differ in principle from those above enumerated.

The chief wood-pulp producing countries in Europe are Norway, Sweden, Finland, Germany, and Austria-Hungary. Of these the two first named are the largest exporters. Finland, which formerly exported to this country, now sends her produce almost exclusively to Russia, where she enjoys the double advantage of proximity and protection. Germany and Austria-Hungary have until recently found a sufficient outlet in the home market, but consequent upon the great increase of production which has taken place in the last few years, their exports have increased, especially in wood-pulp boards.

Full and reliable statistics are not to be obtained, the Custom-House Returns including such dissimilar articles as chemical and mechanical, dry and moist pulps and wood-pulp boards under one generic name. Another source of error is to be found in the fact that wood-pulp boards, straw-boards, and mill-boards are sometimes returned as "paste-boards," while pure wood papers are generally described as "paper." The following figures, however, incomplete though they be, may be found of some interest.

Norway exported—

From 1866 to 1870, . .	110	tons of wood pulp	annually.
,, 1871 to 1875, . .	4,600	,,	,,
In 1876, . .	12,200	,,	,,
,, 1877, . .	14,900	,,	,,
,, 1878, .	19,000	,,	,,

The declared value of the exports in 1878 was 1,200,000 kroner, or about £66,000, representing the produce of twenty mills.

In the year 1880 the imports into the port of Hull were—

Wood pulp, ...	18,964 tons.
Mill-boards, ...	3,935 „

The last item consists chiefly of wood-pulp boards. Probably the imports into all other ports of the United Kingdom do not exceed at the present time 20,000 tons.

France imports nearly the whole of the wood-pulp she consumes. Values only can be given for these imports—

	From Sweden.	From Norway.
1873, ...	£1,628	...
1874, ...	15,694	£11,659
1875, ...	28,611	11,613
1876, ...	39,569	34,339
1877, ...	41,751	36,675
1878, ...	22,040	21,101
1879, ...	23,900	19,555
1880, ...	26,011	21,884

The number of mills manufacturing wood-pulp of some kind in the year 1883, is ascertained to be as follows :—

Germany, ...	418 mills.
Austria-Hungary, ...	154 „
Sweden, ...	53 „
Norway, ...	34 „
Switzerland, ...	11 „
Total, . .	670 „

Ground wood-pulp came into use in the United States in 1859, but the consumption increased very slowly until about 1870. The wood-pulp makers are protected by a heavy import duty, which has doubtless helped to foster the industry. At present the yearly production is said to be worth $10,000,000, and taking the average value for all kinds to be three cents per lb., this would show a yearly output of 148,809 tons. These figures differ from those given by Mr. Pease in New York, who estimated the consumption of mechanical wood-pulp at 150 tons daily, and of chemical pulp at 75 tons daily ; or together, 82,125 tons annually ; and this is probably the more correct.

CHIEF WOOD-PULP PRODUCTS.

Chemical pulp (cellulose) is used as an adjunct, with esparto, rags, or mechanical pulp, in the manufacture of news, printings, colours, and some kinds of wrapping-paper. It forms (according to Mr. Routledge) an excellent *succédané*, or filler-up, and bleaches to a high colour. There is besides a class of paper made entirely from this material, unbleached or self-coloured. Fine printings are also manufactured exclusively from Ekman's acid pulp at Ilford Mill, and, so far as we know, not elsewhere.

Mechanical pulp is chiefly used as an adjunct in the manufacture of news, cheap printings, and wall-papers; but there are several distinct classes of paper made from it without any other ingredient, viz. wood-pulp middles from white pine pulp, and various self-coloured wrappings and tinted wall-papers from brown, sometimes styled "patent" pulp.

Another important use is for wood-pulp boards and so-called "patent" or brown boards, the latter being produced from brown pine pulp, and the former from white pine pulp. The consumption of wood-pulp boards is increasing rapidly. They are used as a middle, and also, this being their chief use, for making paper boxes. For the latter purpose they possess certain advantages over straw boards (a cheaper article), viz.—(1) their colour, being like that of toned paper, the boxes do not require to be lined or covered with paper; (2) their specific gravity is less than that of straw boards by about 30 per cent.; (3) they are free from smell, which renders them preferable to straw boards for boxes destined to contain comestibles, confectionery, etc. As the cost of wood boards is becoming yearly more nearly equal to that of straw boards, it seems not improbable—considering the cheapness and abundance of the raw material—that they may eventually supersede the latter article for most purposes.

The following account of the process of making wood-pulp boards is given on the authority of one of the largest of the Austrian makers. The wood must be first carefully freed from bark and knots, and cut into suitable lengths. It is then pressed against the rim of a revolving grindstone from four to five feet in diameter, under a continuous shower of water, which prevents the wood from heating, and washes off the fibres as they become detached in the process of grinding. The water, containing both coarse and fine fibres in suspension, is then conducted across sieves or strainers which are kept in shaking motion. The coarser fibres which remain in the strainers are again passed between millstones very similarly arranged to those of a flour-mill, to be further disintegrated. If the wood pulp is destined for paper-making, this process must be repeated several times. For boards, however, it suffices if the greater part of the coarse fibres is removed. The machine used for making wood pulp into boards is very simple in construction. It consists of a cylinder *a* (Fig. 21), with close ends, the circumference being covered with brass wire gauze (like a drum-washer), which is made to revolve slowly in a chest into which the wood-fibres and water are continually flowing. The water passes through the wire-gauze, leaving on the surface a thin layer of fibres, which is conducted on to an endless felt in the usual way at the roll *b*. The layer is carried by the felt between the heavy rolls *P* and *F*, and the felt, now freed from fibres, is conducted to *C*, where it is well washed and beaten by a mechanical contrivance. The roll *F* has two grooves on the rim running parallel to its axis, and when the desired number of layers (which may vary from four to sixty) has been attained, they are cut off the roll along these lines, thus giving two boards of the same length as the roll and of a breadth equal to half its circumference. The boards are then

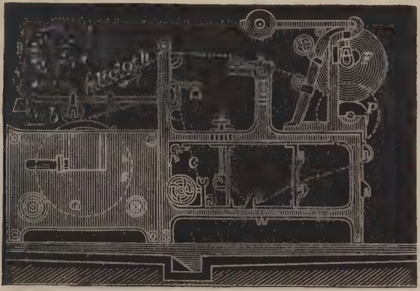

FIG. 21.—Machine for the manufacture of Mechanical Wood-pulp Boards.

subjected to hydraulic pressure; but they retain 50 to 60 per cent. of water, and must be dried either on cylinders heated by steam or in the drying-loft.

The process of making "patent" or brown boards is precisely similar to the above, with the exception that the wood, before grinding, is boiled in water for sixteen to twenty-four hours under a pressure of from three to six atmospheres. A water-power of sixty horse-power is calculated to produce by one stone about sixteen cwt. of wood-pulp boards per diem. Trees of an average growth of forty to fifty years are used, whereas such trees for building purposes are allowed to stand eighty to a hundred years. 1000 kilogrammes dry wood yields about 750 kilogrammes of pulp boards.

The fine granulated sandstones used for grinding are generally obtained from the large quarries on the Elbe above Dresden.

WOODS BEST SUITED FOR PULP-MAKING.

Although almost any wood can be converted into pulp, experience has hitherto decided in favour of conifers of a certain age. For chemical pulp, trees on an average of twenty years' growth, and of a thickness of 6 to 8 inches at the base of the stem are said to be the best. Younger wood is more tractable by chemical means, but produces a fibre of inferior quality, and if used it should be treated separately. Older wood requires stronger chemicals to remove the incrusting matter, and possesses no compensating advantages.

The only other wood besides pine or fir used largely in Europe is aspen or poplar. It is dearer in Norway and Sweden than pine wood, on account of the demand for it in the manufacture of lucifer-matches. The fibre produced is tender and short, but much whiter than pine fibre; hence a higher price is obtained for the ground wood.

In America and Canada many species of wood have been utilised, amongst which may be mentioned pine, poplar, spruce, willow, black gum, basswood, magnolia, cedar, hemlock, maple, birch, cotton-wood, and linden.

Poplar pulp remains white, birch becomes pink, maple turns of a purple tint, and basswood reddish, after grinding.

The present price obtained in America for spruce pulp is $2\frac{1}{8}$ cents, and for poplar pulp $1\frac{7}{8}$ cents per lb.

So far as we know, no exhaustive experiments have yet been made to decide the relative values of different woods for pulp-making. The points to be ascertained are—(1) cost, (2) yield of fibre under the two methods of chemical treatment, (3) the quality of the product. It is a question whether some kinds of home-grown wood, such as larch, willow, and alder, might not be advantageously used in certain localities. If this could be practically demonstrated, it would aid the agitation for re-afforesting some of the hills and waste lands of the British Islands, and give a fresh impulse to the woodman's craft.

It will doubtless occur to many that sawdust and shavings, being waste substances, might be utilised for pulp-making; but no practical method of treating either has yet been discovered, and for opposite reasons. The former is too dense to allow of the necessary circulation of lye in the boiler, and so becomes charred; and the latter is too bulky to treat profitably, because the lye must be of a given strength, and that would be sufficient to reduce an equal cubic measurement of solid wood. Another difficulty is the elimination of the sections of knots in the shavings, which, if left in, would render the products valueless for fine papers. Some kinds of waste, however, may be, and are, utilised, viz., deal and batten ends and the chips from clog factories; but should any large demand spring up, such supplies would soon be exhausted, and the papermaker would have to depend mainly upon round wood for his staple supply.

PULPING PROCESSES.

The systems hitherto extensively used may be conveniently divided into three classes—(1) mechanical processes for grinding wood in contact with water, of which Voelter's process is the type; (2) the process for making brown pulp, in which the wood is boiled under pressure without chemicals before grinding; (3) the reduction of the wood by means of chemical agents at a high pressure and temperature. In the mechanical process there are two classes of machines chiefly used—one worked with a vertical stone (system Voelter) and the other with a horizontal stone (system Sylrecht). In each the wood is reduced on the outer rim of the stones. Another system was patented in 1882 by Wirth, by which the wood is pressed in an oblique direction against one or both sides of a vertical grindstone ; it is thus reduced in a direction parallel to its grain, and so yields a longer fibre. It is probable, however, that a more perfect mechanical process has yet to be found, and it is by no means certain that grindstones will be a necessary part of it. A machine has lately been patented in America which is capable of producing a fibre about 1-6000th of an inch in diameter and of any required length, and which is said to effect a great economy in motive-power over the old methods. Perhaps this may be a first step in the direction indicated. The felting power of mechanical wood pulp and its colour are what chiefly concern the papermaker, and it should be remembered that the former is in an inverse ratio to the diameter of the fibre. Its length is a secondary matter.

Of the second process by which brown pulp is made there is little to be said. The wood being boiled under pressure before grinding, is softened, and while much of the incrusting matter remains, it is entirely freed from the brittleness which distinguishes it in the ordinary state, and so yields a long tough fibre, which is fit for making a good strong wrapping-paper without any further treatment. The natural colour is a light buff, and it is practically unbleachable. It will, however, take various neutral tints and colours suitable for wall-papers, etc.

The processes of Watts, Houghton (1858), Sinclair (1869), and Brown (1874), for obtaining chemical wood pulp are identical in principle, employing high pressure and strong alkaline solutions, and differing only in mechanical details. It is usual to prepare the wood by chopping it across the grain into thin sections, and afterwards crushing it between heavy rollers. It is a matter of some surprise that all the mills (with, we think, three exceptions) which erected boilers for making chemical wood pulp in this country have since discarded them, while the process is still flourishing in Norway, Sweden, and elsewhere. The process itself is simple, and presents no more difficulty than the treatment of esparto, except the use of high-pressure steam.

In what is known as the acid processes the active principle employed is sulphurous acid in combination with a base—lime, soda, potash, or magnesia. Although rival systems (which are all based on Tilghmann's patent, 1866) have lately excited much attention, it has not yet been practically demonstrated that they have any advantage over the soda processes in the essential point of cheapness of production. The elements in their favour are—(1) the employment of lower pressure in boiling, 6 atmospheres being found sufficient; (2) the greater yield—48 to 50 per cent., as against 33 per cent.; (3) the cheapness of the chemicals used. On the other side must be considered the expensive nature of the plant required, and the mechanical difficulty of working lead-lined boilers owing to the unequal expansion and contraction of lead and steel. This obstacle Graham is said to have overcome by his system of amalgamating the lead lining with the iron, and he has an experimental boiler now working successfully in Lancashire. Whatever the ultimate issue may be of the contest now commencing between the soda and acid processes, too much importance should not be attached to the saving in raw material by the latter, when we consider how small a proportion of the ultimate cost it represents. The same reasoning applies to the question of chemicals, for although caustic soda is dearer than sulphites, 90 per cent. can be recovered at a small expense. It is evident that the battle has to be fought out on the ground of comparative cost of working and relative value of the products obtained, rather than on any other.

In connection with the acid process, it is stated that certain bye-products are obtained which offer to the chemist a promising field of research.

Cost as compared with other materials.—Although the cost of producing chemical wood pulp by the various systems is a subject of controversy amongst those best qualified to form a correct opinion, it may be useful to point out that the disputes do not turn so much on the cost of the raw material as on the cost of manipulation. In addition to rags and other waste, there are three materials available for the British papermaker

—esparto, straw, and wood. Of these three wood is unquestionably the cheapest and most abundant, but at the same time it is the most intractable. Assuming that to make one ton of paper about two tons of esparto, two and a half tons of straw, or three tons of wood are required, the cost will be approximately :—

2	tons esparto,	at £7 per ton,	delivered, . .	£14	0	0
2½	,, straw,	at £3 ,,	,, . .	7	10	0
3	,, wood,	at £2 ,,	,, . .	6	0	0

These figures are only approximate, the cost varying with the markets and the situation of the mill; but they seem to show that the possibilities at least are in favour of wood. The relative values of staple produce may vary a little with circumstances, but experience has shown us that the raw material is the least variable factor in the cost of a manufactured article, while the processes employed tend constantly towards cheapness, through improved machinery and better methods.

XIX.

PREPARATION OF WOOD-PULP BY THE SODA PROCESS.

By T. Anderson Reid, Mem. Soc. Chem. Ind.

An opinion as to the suitability of any crude fibrous material for paper-making requires to be formed by acquiring a knowledge of its structure and chemistry. The neglect of such preliminary knowledge has led to the waste of much time and money in attempting to extract fibre from material that contained it in too small proportion to be workable.

The branch of any tree over three years of age shows in a transverse section an arrangement into bark, wood, and pith. The outer layer of bark is corky and non-fibrous, the inner layers are fibrous, and the wood is made up of bundles of fibres, while the pith is generally cellular and devoid of fibre.

A solution of caustic alkali, or of a mineral acid, under ordinary pressure, acts on bark, dissolving the corky portion, and leaving the fibrous part. Such solutions have little action on wood, but they act energetically on pith, dissolving all but a little amorphous matter, which is an altered and non-fibrous form of cellulose.

A thin semi-transparent slice of common wood placed on a glass slide, and moistened with water, appears, under a high-power microscope, to be made up of fibres, with a rough outline, lying close together. If a similar slice of the same wood, which has been soaked for forty-eight hours in nitric acid, be examined, it will be found that whereas the fibres in the previous slice appeared to be held together, the fibres in the chemically treated specimen seem to be at some distance from each other. They also appear thinner, and of a smooth outline. Some of the fibres, moreover, seem more transparent than others, this being due to the varying thickness of the fibre walls. The difference between the two sections is that the nitric acid has removed the incrusting matter, or, as it has been erroneously called, intercellular matter, which in the wood in its ordinary state binds the fibres together. Caustic soda and other reagents, under steam pressure, are also capable of dissolving this matter, with the result that the fibres are loosened and the wood becomes soft. Chemically the incrusting matter closely resembles the fibre wall, but in the process of growth and thickening the outermost layers are hardened, and so crust over the fibres.

In addition to the incrusting matter, the wood contains moisture, mineral salts (in grasses, much silica), resin, tannin, albumen, etc., and, if dry, air.

The Table on the following page shows the woods most suitable for fibre-making; the results are deduced from actual experiment extending over many months. It is to be noted that the digestion was carried on by direct heating, and not by steam. From this it will be seen how it was possible to employ such weak soda solution.

The practical operations concerned in the manufacture of pulp from wood may be conveniently divided into the following:—

1st, Barking.
2d, Sawing.
3d, Chopping.
4th, Crushing.
5th, Boiling or Digesting.
6th, Washing and Bleaching.
7th, Treatment for Sale as "Half-Stuff."
8th, Soda Recovery.

What is here described is the chemical process of making wood pulp, and that by treatment with a solution of caustic soda. Much attention is being given to the acid process, in which acid compounds of sulphur are employed, but as yet no advantages seem to have been gained, especially if the relative

REID'S RESEARCHES ON WOOD-FIBRE.

TABLE SHOWING YIELD OF AIR DRY FIBRE FROM AIR DRIED WOODS, ETC.

Experiments made in the MERSEY WOOD WORKING COMPANY'S LABORATORY, 1882.

Name of Wood.	Description.	Ratio of Wood to Soda Solution.	Density of Soda Solution. Water = 1000.	Equivalent in 70 per cent. Caustic Soda.	Temperature of Digestion—Degrees Centigrade.	Equivalent in lbs. per Square Inch.	Yield of Fibre.	Character of Fibre.	Result of Bleaching Agents.	For what Class of Paper suitable.	Green wood: Moisture per cent.	Yield Fibre per Ton of Green Wood, as per working results. cwt. qr. lb.	Value.
Alder, . . .	Medium	1·3	1065	19·3°/₀	176	130	26·0	Short	Fair colour	Various	42·0	3 0 0	As waste
Ash, . . .	Hard	,,	,,	,,	,,	,,	26·2	,,	,,	,,	28·7	3 3 0	,,
Bamboo, . .	Fibrous	,,	,,	,,	,,	,,	31·0	Extra long	Pure white	Best papers	...	6 0 22	Profitable
Beech, . . .	Hard	,,	,,	,,	,,	,,	38·5	Short	,,	Various	39·0	4 2 20	As waste
Birch, . . .	,,	,,	,,	,,	,,	,,	41·7	,,	,,	,,	31·0	5 2 11	,,
Boxwood, . .	,,	,,	,,	,,	,,	,,	33·9	,,	Medium	Not used	not examined	*nil*	Not used
Elm, . . .	,,	,,	,,	,,	,,	,,	20·4	,,	wants much care	Little used	44·5	2 1 0	As waste
Hemlock, . .	Soft	,,	,,	,,	,,	,,	37·5	Long	White	Various	45·0	4 0 12	,,
Hickory, . .	Hard	,,	,,	,,	,,	,,	39·0	Short	Bleach badly	Little used	,,	*nil*	Not used
Lignum Vitæ,	Extra do.	1·4	,,	25·9	200	230	13·9	Very short	*nil*	*nil*	,,	,,	,,
Mahogany, .	Hard	,,	,,	,,	,,	,,	32·7	Short	,,	,,	,,	,,	,,
Maple, . . .	,,	,,	,,	,,	,,	,,	29·2	,,	,,	,,	34·7	,,	,,
Oak, . . .	,,	1·3	,,	19·3	176	130	22·0	,,	,,	,,	40·0	2 3 14	,,
Pine, Pitch, .	Soft	,,	,,	,,	,,	,,	38·0	Long	White	Various	39·0	4 2 0	As waste
,, Yellow, .	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	50·0	4 2 14	,,
Poplar, . .	,,	,,	,,	,,	,,	,,	41·0	Medium	,,	,,	39·7	4 0 11	,,
Scots Pine, .	,,	,,	,,	,,	,,	,,	38·8	Long	,,	,,	37·0	4 2 17	,,
Spruce Deal,	,,	,,	,,	,,	,,	,,	38·0	,,	,,	,,	27·0	4 3 6	,,
Sycamore, .	Hard	,,	,,	,,	,,	,,	22·3	Short	Fair	Not used	not examined	3 1 0	Not used
Walnut, . .	,,	1·4	,,	25·9	200	230	27·0	,,	,,	,,	,,	*nil*	,,

NOTE.—The last column holds good only when Timber commands a high price. It would pay by the yield shown "to work from Green Wood," if operations were conducted on the spot, and the green wood could be obtained for about 12s. per ton, as is the case, for instance, in Ireland.

prices of soda- and acid-made pulps be compared. There is, again, the disadvantage in the use of acid solutions, that the boilers, unless well protected internally, become speedily corroded. As yet it is an open question if any of the linings proposed have overcome this difficulty.

BARKING—1*st Operation.*—In this description it is assumed that round timber is being worked, and since the bark is for the most part of a non-fibrous character, it is useless for fibre-making purposes. Too much stress cannot be laid upon the necessity for excluding every trace of bark, as it not only consumes the soda solution, but reduces the quality of the pulp. The operation is a manual one, and being of a light character, can be performed by boys. The tool employed is a chisel-shaped piece of steel, about three inches wide, fixed to a handle about two feet long. The edge, being inserted into the bark, is pressed down until it meets the wood; the handle is then drawn back, and the bark comes away. The process is a slow one to a beginner, but in a short time, especially if the operator is paid by the piece, great despatch is attained. The bark may be used as fuel.

SAWING—2*d Operation.*—The barked wood is generally cut by circular saws, and when large timber is employed, it need not be sawn smaller than ordinary railway sleepers. The sawdust which results is not used for pulp-making, for, although samples have been made from sawdust, it is not economical to use it on the large scale, the pulp being rather specky, and bleaching badly. In large towns the sawdust is readily sold for stable use. The operation of sawing is usually done by the piece, and being of an unskilled character, satisfaction is given by this method to both employer and employed. It may be mentioned that in making pulp from bamboo canes, the knots have to be sawn out, as they do not digest well. After being freed from knots, the bamboos go through the same treatment as wood.

CHOPPING—3*d Operation.*—After the wood is sawn, it is conveyed to the chopper, which is a cast-iron wheel running at a high rate of speed. It is generally about five feet diameter, and three inches thick. On the periphery are fixed the moveable cutting-knives, which are of steel. The wood being fed at an angle of 45° against the revolving knives, is sliced obliquely. The pieces vary in size, but are about an inch and a half thick. The wood as it is cut falls into a pit, from which it is elevated by a system of buckets fixed on a belt, and conveyed to the crushing apparatus.

CRUSHING—*4th Operation.*—The wood is crushed in the crushing, or "bark mill," as it is sometimes called, which is driven at a high rate of speed, and is constructed on the principle of the ordinary coffee-mill. By this operation the wood is reduced and broken, so that it offers a large surface for action in the digesting process, and knots are also broken up. After falling from the crusher the wood drops on to a perforated zinc table, where any sawdust falls away, and it is then ready to go into the digester for chemical treatment.

BOILING OR DIGESTING—*5th Operation.*—After the wood has undergone the necessary mechanical preparation, it is ready for digesting, and as this is an essentially chemical process, and one in which the whole secret of good pulp lies, it is worthy of detailed description. The process is based on the fact that wood, when heated to 330° to 350° Fah. with a solution of caustic soda for some time, becomes softened, and rendered fit for the making of paper.

The digesters are vertical wrought-iron cylinders, about sixteen feet high, and four and a half feet in diameter, double riveted, and constructed to stand a working pressure of 130 lbs. per square inch. A manhole door at the top serves for the introduction of the wood, and can be bolted down when the digester is in use. There is a perforated false bottom, and what is called a *vomit-pipe;* it is a ∩-shaped tube, the bend of which is perforated with numerous holes. The ends of the ∩ pass under the false bottom, and the bend comes up to the top of the digester. The steam to work the vomit-pipe enters one of its free ends below the false bottom, and forces the liquid up to the bend through the perforations of which it falls in a shower on the wood. A pressure gauge is fitted to each digester, and there is a blow-off pipe at the lowest point, as well as a ten-inch discharge pipe.

The heating is done by steam admitted by a valve at the top from a special boiler, called the *generator*, which also supplies steam to the vomit-pipe.

The use of the vomit-pipe is apt to dilute the soda solution from the amount of condensed steam, and no particular advantage is gained by it. A perforated rose fixed to the supply pipe of the alkaline liquor seems to me to be a much better arrangement.

Having seen that the valves at the bottom of the boiler are closed, the wood may be put in, the tap in connection with the soda solution opened, and the liquor allowed to run in by the rose. About 900 gallons of 18° Twaddle liquor is required for a charge of wet wood, averaging about 35 to 40 cwt. When the boiler is full the lid is bolted on, all connections closed, and the steam turned in. The pressure comes up to 125 or 130 lbs. in about an hour and a quarter, depending of course on circumstances, and it is kept at this point for two hours. The steam is then shut off, the blow-off valve opened about a quarter, and the liquor blown into a tank for future treatment (see 8th operation). When the liquor is blown off, which will usually be when the gauge has fallen to 80 lbs., the steam may be more quickly got rid off by cautiously slackening the manhole cover. Ten minutes will suffice to get the pressure down from 80 lbs. to 0, and the cover may then be taken off and the stuff washed down into drainers (large wrought-iron boxes with false bottoms of zinc). A good supply of water turned on from a hose over the stuff will save much time in the washing process. One point which calls for further attention in the blowing off is the smell of the spent liquor. In towns or populated districts this is apt to occasion interference by the authorities. I would suggest as a remedy, that the blow-off pipe be connected to a wrought-iron coil of $1\frac{1}{2}$-inch piping, placed in a tank filled with cold water. On the valve being opened the spent liquor would pass through the pipes surrounded by cold water, and so get cooled before going into the storage tanks. The waste steam would also serve a useful end in heating water for any purpose required, instead of passing into the air, charged with liquor spray.

I am of opinion that a digester heated directly by "gaseous fuel" would serve the purpose better than one of the form described, and from experiments I find that wood can be digested with 20 per cent. of 70 per cent. caustic soda against 26 per cent. of the same soda by steam-heating. Steam-heated digesters are expensive in first cost, and require more soda for digesting the wood, while the spent liquor is more dilute than that from direct fired boilers, and consequently requires more coal in furnacing for recovered soda.

WASHING AND BLEACHING—6*th Operation.*—The process of washing and bleaching the digested wood is the same as that carried out upon other fibres. The pulp is thrown into an ordinary washing-engine, a copious supply of good water turned on, and the drum started. This treatment is continued until the wash water comes away clear. If the pulp is to be sold as "half-stuff," 20 gallons of bleach solution (a solution of ordinary bleaching-powder) of 7° Twaddle are added, and the roll kept running for about twenty minutes. At the end of this time the water and drum are again employed, and the pulp washed, and it is then run into the machine chest (see next operation). If the pulp is to be converted into paper on the spot, it is generally mixed, after washing, with other fibres, and manufactured in the usual manner.

Sulphurous acid has been proposed as a substitute for chlorine in bleaching, but, as applied to wood, it does not give a permanent decoloration. Where a special and pure white might be desired quickly the following method gives good results:—A dilute solution of potassium permanganate is added to the washed pulp and allowed to stand thirty minutes. To the brownish-red mixture sulphurous acid solution is then added, mixing all the time until it is in slight excess, and then the pulp must be washed well. Care must be taken not to run in too much sulphurous acid, and great attention must be given to perfect washing.

When the pulp is bleached by chlorine in the heat the advantage gained by rapid decoloration is counterbalanced by the action of chlorine on the fibre making it brittle when dried.

Some woods, like hemlock, spruce, alder, ash, etc., require more chlorine than others, this being due to oxidation of matters present which the soda has not removed, but which are destroyed by the calcium hypochlorite of the bleach.

Treatment for Sale as Half-Stuff—7*th Operation.*—The washed and partly bleached pulp is run through a set of knotters, to retain any stray pieces of wood, and thence it passes to the machine. Being sold usually as containing 50 per cent. moisture, the sheet of pulp, after passing through the couch roll, passes between a pair of polished cold iron cylinders, and on to the end of the machine, where it is cut into sheets. The sheets are then made into bales by hydraulic pressure, and covered with bagging, when the stuff is ready for transit or export. The bales usually average four cwt. in weight. From a charge of thirty-five cwt. of wood in a green state six bales are obtained, equal to about twelve or fourteen cwt. dry fibre.

Soda Recovery—8*th Operation.*—The process of recovering the soda from spent alkaline liquors consists in boiling down until free from water, and subsequent furnacing to burn out organic matters. The spent liquor contains, in addition to the soda originally used in the boiling operation, extractive matters from the wood, such as converted incrusting matter, resin, tannin, etc., and these during furnacing are burnt out, the carbon going to form sodium carbonate with the soda. The average strength of spent liquors from wood boiling is about 18° to 20° Twaddle.

The recovery plant consists of storage tanks, furnace, causticiser, and filter.

The storage tanks are generally placed over the furnaces for convenience. A reverberatory furnace, lined internally with firebrick, is usually employed. Inside the furnace, above and parallel to the bottom, are iron trays for boiling down the liquor before it is allowed to run on to the furnace bottom.

The liquor, after being run into the tray, is boiled down until of about the density of 80° Twaddle when hot. When sufficiently concentrated it is run on to the furnace bottom, and worked frequently over. In a short time decomposition sets in, which may be known by the surface becoming beaded over. After this the stuff commences to burn, and care must now be taken that the furnace is not overheated, otherwise the charge will fuse. When gases cease to be evolved, and a sample taken out is porous and greyish white, the charge may be drawn. It should contain from 50 to 53 per cent. alkali.

The soda or *black ash* is now ready for conversion into caustic liquor. The rationale of the process is that when a moderately weak solution of sodium carbonate is treated with caustic lime, calcium carbonate is formed, and caustic soda remains in solution. The operation is called "causticising." There are several ways of treating the black ash for caustic liquor. The following is the most economical:—The causticiser, which is a circular iron tank fitted with steam and water pipes, also with an agitator worked by a belt and pulley arrangement, and a discharge pipe, is half filled with water, the agitator started, and steam turned in. When nearly boiling the black ash may be thrown in. When the ash is dissolved the strength is adjusted to 20° Twaddle, the boiling being continued. Lime is added in the proportion of thirteen cwt. to every ton of ash present, at the rate of a cwt. every five minutes, the agitation being well sustained. When nearly all the lime is added, a sample of the liquor is taken out, filtered, cooled, and tested with three or four drops of sulphuric acid (two of water to one of acid). If no effervescence is produced the process is considered to be finished; if effervescence takes place the addition of lime and boiling must be continued until a satisfactory result is attained, when the steam may be shut off. The liquor is now ready for filtering from suspended matters.

The filter is usually the half of an old boiler which has been cut in two longitudinally. On the bottom is placed a perforated iron plate, leaving a space of eight inches between the bottom of the boiler and the plate; on the plate a layer of coarse gravel six inches thick is placed, above this is a layer of fine gravel four inches thick, then a covering of iron gauze, and over all a perforated iron plate.

The discharge valve from the causticiser is opened, and the turbid liquor run on to a filter. The exit-pipe (which should be connected with a pump) at the bottom of the filter has its valve opened, and the clear liquor which comes through is pumped away to tanks for the digestion of fresh batches of wood. Some water may be added to the lime-mud, and the extract be pumped into the causticiser to dissolve fresh lots of ash. By this treatment a little soda is usually obtained. The drained mud may then be shovelled out.

The liquor obtained is generally of about 16° Twaddle, so that it becomes necessary to make it up to 24° Twaddle in boiling the wood by injected steam. This is done by the addition of solid caustic soda. If the wood is not treated by the vomit-pipe method it should be made up to 18° Twaddle. With good working 70 per cent. of the soda should be recovered, and that may be set down as reducing the cost of the caustic for boiling by about 50 per cent. net.

UTILISATION OF WOOD WASTE.

The immense quantities of waste produced in saw-mills, and other wood-working establishments, and the almost universal disposal of this by burning, calls for a little consideration. From results obtained by eminent authorities, it appears that one ton of good nut slack is equal to three tons dry wood from a heating point of view. Taking the Liverpool price of good nut slack at 7s. 6d. per ton, from a calorific consideration of the case, wood becomes in value 2s. 6d., or one-third of 7s. 6d. per ton. This in itself is a good argument against the use of wood waste as a fuel. The great hindrance to the use of wood waste for the production of pulp is that in small sawmills enough could not be obtained to keep a moderate-sized plant going. As a suggestion, I would propose the formation of a centrally situated fibre-mill, so that from a given radius supplies could be drawn from saw and other factories from which wood waste could be obtained. Even if such waste cost £1 per ton, delivered to the pulp-mill, it would pay. The waste generally consists of what is known as "dubbings," and this is a short chippy shaving in a condition for boiling without any mechanical treatment whatever. Of course, from a mixed class of wood, as would naturally be obtained from various sources, it would hardly be possible to make a high-class and uniform fibre, but for news and similar grades of paper it would give a satisfactory result.

Pulp with an excellent fibre and fair colour has been made from old railway sleepers. There is however some difficulty in removing the oily matter and creosote with which, as a rule, the sleepers are pickled. A good method of treatment, after boiling the wood in the usual way (as described under 5th operation), is to blow the liquor off. Leaving the manhole cover on, pump in boiling water, turn on full steam, and open the blow-off valve, and allow the injected water to blow off. The effect is to carry off all the oily matter, leaving a pulp that gives a fair colour on submitting to bleaching agents.

COMPARATIVE COST OF MAKING PULP FROM WOOD AND ESPARTO.

It is said that good esparto gives 50 per cent. fibre on digestion ; dry wood gives on an average one-third, or 33·3 per cent. of its weight. The cost of making pulp from wood and esparto respectively is stated below. It will be seen that I have allowed a good margin in the case of wood for exigencies, viz. one-fifth, or 20 per cent. In the case of esparto I have only given 10 per cent.

Pulp from Wood.

Basis 33·3 per cent. yield.

Three tons wood, say 25s. per ton, ...	£3	15	0
Mechanical treatment, say 7s. 6d. per ton, ...	1	2	6
Caustic for boiling 25 per cent. of 70 per cent. caustic = 15 cwt., at say 10s. per cwt., ...	7	10	0
Washing and bleaching, say 5s. per ton, ...	0	15	0
	£13	2	6
Add 20 per cent. for exigencies, etc., ...	2	12	6
	£15	15	0
Less 50 per cent. net of soda used, this quantity being recovered, ...	3	15	0
	£12	0	0

Cost of making one ton fibre, . . £12

Pulp from Esparto.

Basis 50 per cent. yield.

Two tons esparto, say £6 per ton, ...	£12	0	0
Mechanical preparation, say 5s. per ton, ...	0	10	0
Caustic for digestion, say 10 per cent. of 70 per cent. = 4 cwt., at 10s. per cwt., ...	2	0	0
Washing, etc., say 3s. per ton, ...	0	6	0
	£14	16	0
Add 10 per cent. for exigencies, etc., ...	1	9	7
	£16	5	7
Less 50 per cent. soda used, this quantity being recovered, .	1	0	0
	£15	5	7

Cost of making one ton esparto fibre, . .	£15
" " wood " . . .	12

In favour of wood, £3 per ton of fibre produced.

The figures given for wood may be considered, as far as expense is concerned, a maximum. In places where there is an abundance of timber the cost would be very much less than 25s. per ton.

XX.

REPORT ON WOOD-PULP PROCESSES.

By C. F. Cross and E. J. Bevan.

The object of this report is to give such an account of the various processes for the preparation of "chemical" wood pulp as shall put before paper manufacturers the grounds which practical science shows for some radical change from the materials and methods now in use to others which are either designed to overcome their defects or which present superior positive advantages. In order to address ourselves the more directly to this practical object, we shall limit our report to the consideration of the treatment of coniferous woods, as it is to these that the attention of papermakers in this country must necessarily be chiefly confined.

The most obvious advantages of wood as a raw material for paper-making are these: (1) small first cost, pine wood costing in this country from £2 to £2, 10s. a ton, and yielding under suitable treatment from 40 to 50 per cent. of a high-class paper-maker's cellulose; (2) freedom from mineral and other impurities, the presence of which involves a process of screening or other methods of removal, often giving imperfect results; (3) the superior paper-making qualities of the fibres into which it may be resolved.

The disadvantages of the older systems of treatment, as applied to pine wood, are: (1) the costliness of the process, both directly as regards consumption of chemicals and fuel, and indirectly, as regards the comparatively low yield of fibre, and the degradation of the soluble bye-products into substances of no value; (2) the deteriorating effect of the treatment upon the cellulosic product. These defects have been considered to outweigh the advantages, and have prevented the processes from rivalling to any great extent those in which esparto, straw, etc., constitute the raw material.

The more recent investigations and achievements of technologists have, however, shown that by a system of treatment chemically the opposite of the older alkali method, wood gives results showing a very important economical advantage over those obtained from all other raw materials.

To treat the subject properly it will be necessary to show very clearly the distinction between the older and the more recently adopted processes, and it is impossible to do this apart from a consideration of the principles on which they are based. We shall therefore consider so much of the chemistry of wood as is necessary to the understanding of the processes and the antithetical relationship which they hold to one another.

Coniferous wood (*Pinus abies*) has been investigated by Erdmann. He obtained results such as to justify him in regarding it as substantially homogeneous, that is, as a chemical individual, and this view is expressed by the term glycolignose ($C_{30}H_{46}O_{21}$), which he has applied to the essential constituent of woods of this group.[1] We have ourselves devoted some time to the chemical investigation of jute, which was taken as the simplest type of lignified fibre, and which we have individualised by the term "bastose," indicating thereby a substance possessing uniformly characteristic properties. Erdmann's glycolignose and bastose are so closely similar that all that has been established for the latter may be taken as applying, in general outlines, to the former.

Accordingly we regard glycolignose as a compound cellulose, the product of the union of cellulose with other substances which may be conveniently included in the term non-cellulose.

For the purposes of the papermaker it is necessary to decompose this compound body, so as to isolate as completely as possible the insoluble cellulose of which paper is composed. Although in its better known forms cellulose appears to be an inert substance, it is only relatively so. Wood cellulose we have shown reason for regarding[2] rather as an oxy-cellulose, *i.e.* one of a group of cellulosic derivatives, differing from the ordinary or typical cotton cellulose by possessing well-marked chemical activity, and especially by being susceptible of oxidation and hydration, and of conversion thereby into substances of the pectic group. Hence it is by no means a matter of indifference what the conditions are to which cellulose is subjected in the boiler, and it will be manifest that an alkaline treatment under oxidising conditions not only converts a portion of its substance into soluble products of degradation, but modifies the insoluble residue, physically and chemically, in directions which it is important to avoid. A study of the chemistry of the oxy-celluloses will make this clear.[1]

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[1] *Ann. Chem. Pharm. Supp.* iii. 223.

[2] *Journ. Soc. Chem. Ind.* iii. 206.

The most advantageous process of resolution will necessarily be that which conserves the insoluble cellulose at the same time that it attacks the non-cellulose constituents of the wood with the least amount of change consistent with their conversion into soluble derivatives. These constituents have one prominent feature—they belong to or are immediately resolvable into derivatives of the group of substances known to the chemist as *Aldehydes*.[2]

The aldehydes are amongst the most active of chemical compounds; not only are they greedy of oxygen, with which they combine to form acids, but they combine internally, molecule with molecule, to form complex or multiple molecules (polymerides) without alteration of percentage composition, but with very considerable change in properties: they also combine internally with elimination of water, or as it is termed, they *condense* by, or as the result of, *dehydration*: they combine readily with phenols; in short they are endowed with synthetical activity of a very high and varied order. The products of such combinations are (1) acids, (2) resins and resinous substances, (3) colouring matters: exactly such substances as most unfavourably affect, by combination or other modification, a cellulose with which they are brought in contact. The conditions most favourable to their production are exposure to oxygen and such temperatures or other conditions as determine dehydration. An important feature common to these products is that they tend more and more to resist the further action of the conditions which produced them. And it is difficult to see how otherwise the equilibrium of vegetable life could be maintained. The bark of perennial plants is made up to a great extent of resins, tannins, etc., substances destined to protect the true woody tissues beneath, and formed at the expense of a portion of these by oxidation and dehydration. Any process of artificial resolution, therefore, which admits conditions likely to produce such bodies, will yield a pulp containing such resinous and colouring matters in a state of intimate mixture or combination with the cellulose, and is therefore necessarily imperfect.

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[1] *Bull. Soc. Ind.*, Rouen, 1883, 169 and 240; *Chem. Soc. Journ.* 1883, 22; *Journ. Soc. Chem. Ind.* loc. cit.

[2] The allied group of *ketones* is doubtless also prominently represented.

All processes for the isolation of cellulose from wood depend *primarily* upon a *hydrolytic* resolution of its constituents—they consist, *i.e.* of a splitting up of complex substances, of which the immediate cause is combination with water (hydration)—and *secondarily* upon the removal from the sphere of action of the products of this resolution or neutralisation, and upon the absence of such conditions as favour the formation of synthetical products, *i.e.* which tend to a reversal of the hydrolysis. Theoretically the success of a process depends upon the proper regulation of these two sets of conditions. Some hydrolytic actions are determined by water only, but more frequently the presence of an acid or an alkali as an auxiliary is required, the reagent itself undergoing no change. The conditions which have been classified as secondary are—(1) the combination of the products of resolution with the inorganic substances used in the process; (2) the prevention of oxidation; (3) the prevention or minimising of dehydration.

We are now in a position to give a classification of the various processes upon the theoretical lines here laid down; and we especially wish to direct attention to those based upon the resolving action of solutions of the bi-sulphites in regard to their fulfilment of the conditions postulated by those principles. These are—(1) the conservation of the cellulose, these solutions having, under the conditions required in the treatment, no sensible action even upon the more delicate forms of cellulose; (2) the resolution of the lignose into cellulose and non-cellulose constituents, with the minimum of chemical modification of the latter. The accompanying table (I.) is constructed with

TABLE I.

VIEW OF THE CHEMICAL PROCESSES OF DISINTEGRATING WOOD.

AQUEOUS ALKALIES.

Hydrolysis aided by alkali directly, also indirectly by combination with products.	WATT & BURGESS, 1853.
Reversal of hydrolysis aided by temperature, oxidation, and gradual neutralisation of alkali.	HOUGHTON, 1857.

SOLUTION OF ALKALINE SULPHIDES.

Hydrolysis aided by alkaline bases directly and indirectly by combination with products. Reversal of hydrolysis lessened by presence of reducing agent.	JULLION, 1855. BLITZ, 1883. DAHL, 1884.

WATER.

Hydrolysis aided by acids formed at the expense of the wood. Limit determined by reversal of hydrolysis, *i.e.* dehydration aided by oxidation.	FRY, 1867.

WATER TOGETHER WITH NEUTRAL SULPHITES.

Simple hydrolysis, requiring therefore higher temperature. Products removed from sphere of action by combination with base and with sulphite residue. Oxidation prevented by presence of sulphurous acid.	CROSS, 1880.

AQUEOUS ACIDS.

(*a*) *Oxidising and hydrolytic.*	
Nitric acid.	COUPIER & MELLIER, 1852. BARRE & BLONDEL, 1861.
Nitro-hydrochloric acid.	ORIOLI, 1865.
(*b*) *Simply hydrolytic.* Hydrochloric acid.	BACHET & MACHARD, 1864.
(*c*) *Reducing and hydrolytic.* Sulphurous acid.	TILGHMANN, 1866. PICTET, 1882.

BI-SULPHITES.

Hydrolysis aided primarily by sulphurous acid, and secondarily by combination of products with bi-sulphites, also by prevention of oxidation.	TILGHMANN, 1866. MITSCHERLICH, 1874. EKMAN, 1881. FRANCKE, 1881. GRAHAM, 1882.

special reference to the second condition. Certain processes, those, namely, in which acids other than sulphurous are employed, are introduced rather with the object of theoretical completeness than as having any direct bearing on the main subject of this report.

In the light of our present knowledge of the chemical nature of the celluloses, as developed by the researches to which reference has been made, the general result of a comparison of the various processes by means of the foregoing table shows that, as regards the pulp, one or other of the processes involving the use of sulphurous acid is to be preferred to the older ones in which an alkali is employed. In these days of scientific manufacture, however, we have to consider very carefully the question of bye-products, and in this aspect the sulphurous acid processes hold out the promise of additional advantage. The bye-products of these processes are obtained in a form but little different from that in which they exist in the original wood, whereas by the water and alkali methods the bye-products, as finally obtained, are the result of profound modification of the wood constituents.[1] Perhaps the most striking characteristic of the soluble bye-products obtained by the sulphurous acid processes is their power of forming with gelatine a peculiar caoutchouc-like body, insoluble in water, but freely soluble in weakly alkaline solutions. This action on gelatine has been held to be peculiarly characteristic of the tannins, but it will be found on examination that the substances obtained from wood do not resemble the tannins in any other essential property. It is interesting to note that tannins are formed in nature from wood constituents, such as those of which these soluble bye-products are composed. We have, moreover, shown elsewhere[2] that there is a chemical proof of the genetic connection, thus indicated, between the tannins and the non-cellulose constituents of wood. It remains for the future to show the constitutional resemblance which is expressed in the similar behaviour towards gelatine, and also to disclose the more extended application of these bye-products which their relationship to the aromatic group of compounds would lead us to anticipate.

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[1] For an exhaustive sketch of these products, see *Papier Zeitung*, 1878, 226, 242.

[2] *Journ. Chem. Soc.*, 1880-1884.

Upon the theoretical basis laid down above, we now proceed to base the more practical portion of our task, which is the discussion in detail of the processes which we have selected as typical of the various methods of resolving wood for the purpose of paper-making.

Water Process.—Wood is to a certain extent resolved by treatment with water at a high temperature, the degree of disintegration being within certain limits proportional to the temperature at which it is digested. The volatile products of the resolution are chiefly acids of the acetic series, furfurol and terpenes. The non-volatile soluble products are for the most part acids. This process was studied by Fry, who in 1866 made it the subject of a patent. He found that under the most favourable conditions of treatment the yield of brown pulp amounted to 70 per cent. of the wood used. The objections to the process were sufficiently obvious. The pulp produced was of low quality, and the solution acted powerfully upon the iron digesters employed. The chemical causes of its failure lie in the prominence of the conditions which determine recombinations of the products of resolution with one another, viz., oxidation, high temperature, and the *presence of acids.* It may be interesting to note that in one trial as much acid was developed during the boiling of 6338 parts of dry wood as would require 217 parts of soda (Na_2O), for neutralisation. This was by far the most serious defect in the process, and it eventually caused its abandonment in favour of the older treatment with caustic alkali.[1]

Alkali Processes.—The first to develop the alkali process were Watts and Burgess in America (1853-1857), and Houghton in this country. To follow up the several modifications in detail would be to recapitulate information now common to all. They differ from one another in the economical balance which they strike between temperature and quantity of chemicals: thus Watt and Burgess employed a lye of 12° Baumé, and digested at 60 lbs. pressure (152° C.). Houghton used a lye of 4° B. at 100 to 180 lbs. pressure. One great defect of these processes was the gradual neutralisation of the alkali, requiring as a compensating condition a very high temperature at the close of the operation. To overcome this objection Ungerer devised a process which aimed at securing a properly graduated action of the lye. This process, being based on an eminently rational view of the action of the alkali, is worthy of a more extended notice, especially as the principle on which it is founded is capable of wide application. A system of nine vertical digesters, connected together in series by means of pipes and cocks, so that the liquid contents can be transferred from one to the other in succession, is the main feature of the method employed. In connection with this system there is a double service of pipes, by which the hot soda lye at 90 lbs. pressure, and cold water, may be respectively introduced, the latter requiring the aid of a force-pump. The operation is so conducted that in five of the digesters wood is being treated at high temperatures; in three the pulp is being washed, and one is being filled with a fresh charge of wood. The whole operation may be described thus, giving the digesters numbers corresponding to their position in the series of nine. Nos. 1, 2, 3. Washing the finished pulp; 4. Final treatment with caustic lye at the extreme pressure (90 lbs.); 5. Digesting at lower pressure with liquor previously employed in 4; 6. Treatment at still lower pressure with liquor that has already done duty in 4 and 5; and so on to 8, where the liquor, having passed through the series, is employed at 15 to 20 lbs. pressure upon a fresh charge of wood. The washings are conducted in such a way that the water which is introduced into 1 displaces the solution in each digester throughout the series, the solution from the last being allowed to run to waste. The introduction of the fresh liquor at 4 is similarly accomplished, 1, 2, and 3, being cut off by closing the cocks which control the ingress and egress of liquid.

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[1] See *Journal Society of Arts*, February 1883, p. 225.

The pulp produced by this method is of a sufficiently pale colour to be capable of application for many purposes without bleaching. It is converted into a perfectly white product by treatment in the ordinary way with bleaching powder, in quantity equal to 3 or 4 per cent. of the dry pulp.

As far as it goes, this method is practically perfect, and it appears to have given sound results, at least as regards the main product. The principal disadvantages were the complications attending such an elaborate system of working, which would doubtless make it costly to employ. Upon this question, however, in the absence of trustworthy information, we are not in a position to pronounce. We pass on to the next category of alkaline processes, which are based primarily upon the action of an alkali, but which introduce the simultaneous action of a soluble sulphide, generally that of sodium, as a reducing agent. As far back as 1855 Jullion patented in this country a process of this nature, which however does not appear to have been applied to wood. The results obtained with such substances as straw and esparto seem to have been very unsatisfactory, and to have led to the early abandonment of the method. Recently the increased attention which has been given to wood as a raw material for paper pulp has led to a revival of these sulphide processes for its treatment. We believe that at least two processes of this class are being worked on the Continent, viz., those of Dahl and of Blitz.

That of the former consists in heating wood, at pressures varying from 60 lbs. to 120 lbs. per square inch, with a solution of the following composition:—

37 per cent. . . .	Sulphate of Sodium.
8 „ . . .	Carbonate of Sodium.
24 „ . . .	Hydrate of Sodium.
28 „ . . .	Sulphide of Sodium.
3 „ . . .	Various compounds.

This solution is obtained only after the process has been some time at work, and it then remains tolerably constant.

The wood, to commence with, is boiled with a solution containing a large quantity of sulphate of soda, with a small quantity of caustic soda, obtained by boiling sulphate of soda solution with slaked lime. The liquor from this operation is then evaporated and calcined, the result being a fused mass which, when dissolved, yields a liquor containing the above-mentioned ingredients. The loss of chemicals is made up by the addition to the liquors of sodium sulphate.

From experiments we have made with this process, we have come to the conclusion, that while wood can be pulped by it, it is necessary to employ either very strong solutions or very high pressures. This is equivalent to saying that either the hydrolytic agency is weak, or the tendencies to reversal of the hydrolysis are strong; and indeed both are to be predicted from the composition of the solution. Moreover the pulp is exceedingly difficult to bleach, requiring a quantity of bleaching powder which is prohibitory.

The process of Blitz consists in heating wood to from 50 to 60 lbs. pressure with a solution of sodium sulphide, with the addition of 15 grains of vanadate of ammonia for 127 cubic feet of wood.

As we know well the remarkable effect that small traces of vanadium have upon certain reactions, it would perhaps be somewhat rash to venture *a priori* upon an expression of suspicion of its efficacy in this process. In our experimental investigation we have failed to establish the claim that has been made for it. Although in these sulphide processes a strongly reducing agent is present, its effect in preventing oxidation is more than outweighed in regard to the aggregate result by the weakening of the hydrolytic action of the base, both directly by its combination with the sulphur, and indirectly by the complications which it induces by combination with the soluble bye-products. Further, as regards the final product, it offers no advantage over the old caustic alkali processes. The only apparent gain, indeed, is to be found in the small cost of chemicals used in boiling, and this is more than counterbalanced by the additional quantity of bleaching chemicals required.

Acid Process.—We now come to consider those processes which are based upon the hydrolytic action of acids as a primary condition. We have seen that in the water process this condition obtains as a secondary result, and that while it aids in resolving the wood, it also determines the limit of the action, in consequence of its promoting secondary combination amongst the soluble products. The action of powerful oxidising acids, such as nitric and nitro-hydrochloric, introduces an action which is sufficiently drastic to cause a complete resolution of the non-cellulose constituents of the wood with the formation of soluble products. These have been made the subjects of many patents.

The process of Barre and Blondel consisted in digesting the wood for twenty-four hours in 50 per cent. nitric acid, by which it was resolved into a soft fibrous mass. This was boiled for some hours in water, afterwards in a solution of sodium carbonate, and lastly bleached in the ordinary way. Many other patents have been taken out in this direction, but none have met with any practical success, owing doubtless to the cost of nitric acid.

The resolution of wood by the hydrolytic action of non-oxidising acids is for reasons already stated very imperfect. An important feature, however, of this action is the production of glucose as a bye-product, and a process having the double object of producing this, together with a brown pulp, was patented by Bachet and Machard in 1864, and worked for some time in Switzerland. The process consisted in boiling the wood for twelve hours in dilute hydrochloric acid: the solution, which contained glucose to the amount of 20 per cent. of the weight of the wood, was drawn off, neutralised with chalk, and fermented by the addition of yeast. Alcohol was separated from the fermented liquor in the usual way. The residual pulp, after grinding by stones, was made into coarse packing-paper. The process failed commercially.

The next processes in the order of the development of our subject, but which require for this end to be disturbed from their chronological order, are those involving the use of reducing acids, *i.e.* such as combine with their hydrolytic function a de-oxidising, or anti-oxidising action. Of these the only one which has been practically investigated is sulphurous acid. A particular account of the earlier discoveries in regard to the use of this reagent for the special purpose under consideration will be found in the *Papier Zeitung*, 1884, No. 51, p. 1927, from the pen of M. Schindler, which should be consulted by all those who are interested in the history of a subject which has now grown to be of the first importance. The first patented process claiming the use of sulphurous acid, in the form of its aqueous solution, for the purpose of disintegrating wood, was that of Tilghmann (1866). So far as we can learn, however, the results obtained by the inventor with the acid alone were such as to lead him to abandon it for solutions containing a certain proportion of base. The reasons doubtless were the greater facility of preparation and simplicity of application of such solutions. More recently, Professor Pictet of Geneva, on the basis of the experience acquired by him in the preparation and employment of sulphurous acid for the purposes of his freezing processes, has revived and made perfect a process which in other hands had proved impracticable. The method and the machinery by which it is carried out will be found fully described in the author's specification. The process consists in digesting the wood in closed vessels of suitable construction, with an aqueous solution of the acid (10 to 12 per cent. SO_2) at 80° to 90° C., and under the corresponding pressure (4 to 5 atmospheres). A complete disintegration of pine wood is effected with about sixteen hours' treatment. The yield of pulp is, we are informed, 45 to 50 per cent. of the wood (*Pinus sylvestris*); it is also stated to be easily bleached with usual quantities of bleach, and to yield a pulp of the highest quality. Further, the recovery of the sulphurous acid, for which special apparatus is provided, is practically complete (95 to 98 per cent.), and the soluble bye-products are obtained in a form in which they are directly available for various uses, such as the production of alcohol, or for conversion by dry distillation into acetic acid and colophonium, etc.

This process being as yet undeveloped on the large scale, we can only commend it to the consideration of technologists. At the same time we would draw attention to the features of interest which it possesses in regard to the general aspect of our subject. The resolution which it effects is obviously one of simple hydrolysis,[1] and it affords an indirect proof of the chemical complications which attend all other processes of disintegrating wood, employing as they do temperatures much above the boiling-point of water. The soluble bye-products are obtained in the simplest form, and may be isolated by mere evaporation. As regards the chemical features of the pulp, they will be presumably different from those of any other, whether altogether on the side of advantage it remains for observation to decide. Provided the process fulfils the condition of economical working, we have no hesitation in predicting for it a considerable development in the near future.

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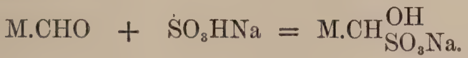
[1] Since ketone groups doubtless play a considerable part in the building up of the substance of woody fibre, their peculiar combining relationship to sulphurous anhydride may come into play as a determining cause of the resolution. See also *Journ. Soc. Chem. Ind.*, January 1885.

The difficulties attending the employment of a gaseous acid have doubtless operated in deterring many, in addition to the originator, from a complete investigation of its action, and have led them to adopt in preference one of its several compounds with bases, the employment of which defines a group of processes to which we now desire to call attention. There are a variety of processes agreeing in the essential feature of employment of a bi-sulphite as the disintegrating reagent, and differing from one another only in the less essential details of method.

The general principle of these processes will be readily understood from what has gone before. The chief agency is the hydrolytic action of sulphurous acid, aided by the conditions of high temperature and pressure; and the subsidiary agencies are—(1) The prevention of oxidation. (2) The removal of the soluble products of resolution in combination with the sulphite as a true double compound. This mode of union is well known to be peculiarly characteristic of all aldehydes,[1] to which class we have shown the wood constituents to belong. The combination is expressed by the general equation—



$$\mathrm{M.CHO} + \mathrm{SO_3HNa} = \mathrm{M.CH}^{\mathrm{OH}}_{\mathrm{SO_3Na}}.$$

Aldehyde. Bi-sulphite. Double compound.

(3) The removal of a portion of the constituents in combination with the base, *i.e.* with expulsion of sulphurous acid.

The verification of these views has been afforded us in the course of a long investigation of the bye-products from the Ekman process. We have also instituted a comparison of this process with others of the same class on the basis of a prolonged series of laboratory experiments, together with such information and products as have come to hand of the working of these processes on the manufacturing scale. The conclusion we have arrived at is that two of these methods, as developed on a manufacturing scale, may be considered as typical, viz., the magnesia bi-sulphite of C. D. Ekman and the calcium bi-sulphite process as developed by Messrs. Macdougall and Partington of Glossop. The working of these we need not enter into in detail, except in so far as it is necessary to compare them. Since, moreover, the differences between the products, both pulp and solution, are comparatively small, we may confine our comparison to the processes.

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[1] It is also characteristic of the ketones, a class of compounds allied to the aldehydes, and, we cannot doubt, largely represented amongst the constituents of wood.

(1.) *The Chemicals employed.*—In both cases sulphur is used as the source of sulphurous acid. We have therefore only to consider the base, and the method of bringing it into combination with the acid. The Ekman process starts from magnesite, from which magnesia is prepared by calcination, and is introduced into lead-lined towers, where it is brought into contact with water and sulphurous acid. The supply of the latter being properly adjusted, a continuous production of a solution of magnesium bi-sulphite of uniform strength is maintained. To secure this uniformity constant attention is of course necessary, and further, the loss of sulphurous acid by oxidation to sulphuric acid, and by simple diffusion, is, in consequence of its distribution over so large a surface, and with free exposure to the air, necessarily very large. It is unnecessary, however, to point out that the preparation of the chemicals is only incidental to the process, and will doubtless undergo modification.

Mr. Partington's method, in addition to the advantage of starting from lime, the cheapest of all basic substances, is free from the disadvantages referred to as attending the use of a tower. It consists in passing the sulphurous gas through a series of three vats, the liquid contents of which are in connection by means of pipes situated near the base. Into these vats a charge of milk of lime is introduced, and the two first being closed air-tight, the gas is passed in. The third remains open to the air, and from it escapes a continuous stream of nitrogen, resulting from the removal of the oxygen by the burning sulphur, from the stream of air which is blown through the sulphur retort at a pressure of 5 lbs. to the square inch. The expenditure for chemicals employed by the latter process is less than £1 per ton of pulp. By the Ekman process it has been variously estimated at from £2 to £3, 10s. Add to this consideration the greater simplicity of the plant, its automatic perfection, and absolute freedom from sulphurous smell, and Partington's must be admitted to be in advance of Ekman's system, as hitherto developed.

(2.) *The Pulping process.*—Ekman uses a lead-lined, jacketed cylindrical boiler, which is stationary. The pressure in the steam space (jacket) is 70 lbs., whilst in the interior it is 90 lbs., to the square inch. The time of boiling is ten to twelve hours. Partington, on the other hand, boils with live steam, and therefore requires a boiler of simpler construction. His digesters are spherical, lead-lined, and rotary. The pressure employed does not exceed 60 lbs. per square inch; the time of boiling is sixteen hours.

(3.) *The previous preparation of the wood.*—The manner of knotting and crushing, and the subsequent treatment of the pulp, do not differ materially in the two processes.

Of the remaining bi-sulphite processes, *i.e.* of their working on the large scale, we cannot speak from experience. Mitscherlich, Francke, and Graham are names which have been before the public in connection with their respective processes for some time, and papermakers have had every opportunity of comparing the merits of their several claims. In their main results, they are doubtless closely similar, as they are identical in the principles upon which they work. In concluding our notice of these processes, we would state that we have been informed upon good authority that bi-sulphite pulp is being produced at a cost not exceeding £11 to £12 per ton; and any process exceeding this amount, in regard to cost of pulp, is open to *a priori* objection.

The cellulosic products of these various processes certainly present differences, but, so far as we have been able to judge from the examination of normal specimens, not such as to constitute a distinct advantage for one or another. One feature of these processes to which but little attention has hitherto been paid, is that of the utilisation of their bye-products. These bodies are, as already explained, in a condition not materially altered from that of the parent substances, the non-cellulose constituents of the wood. The formation of the body precipitated by gelatine as an elastic caoutchouc-like substance, and its re-solution in a solution of sodium sulphite, or of ammonia, is the basis of a patent taken out by ourselves for the preparation, from the bye-products of the bi-sulphite processes, of substances capable of being used for all sizing purposes, and in many other cases where gelatine is at present employed.

The adoption of such a process, or some other effective method of economising these bye-products, will still further reduce the cost of production of paper by the bi-sulphite method.

An objection to all processes involving the use of sulphurous acid or acid sulphites is the necessity of using a boiler lined with lead. The difficulty of coating iron with lead in such a way that it may withstand the expansion and contraction due to the changes in temperature which take place during the operations of boiling, is one which has long been recognised by those who have worked these processes, and will probably continue to be a standing objection to their adoption. A method therefore which avails itself of the protective action of the sulphites, at the same time that it allows the use of ordinary iron boilers, is an obvious desideratum. Such a process is that patented by one of us (Cross, 1880), claiming the employment of solutions of the neutral sulphites, with or without the further addition of alkali. This process, in its application to wood, has not been worked out on the large scale. On the laboratory scale, however, perfectly satisfactory results have been obtained: the pulp is obtained of a pale greyish colour, and is easily bleached. Judging from the results given by straw and jute on the large scale, together with the small trials of wood, there is reason to regard this process as destined to play some part in the development of cellulose technology.

In stating the results of our inquiry, we have endeavoured rather to elucidate the principles which underlie the various processes for the chemical treatment of wood for paper-making than to deal with the less trustworthy, because *ex parte*, statements of their respective achievements. Of these, moreover, the papermakers themselves are the best judges, and our endeavour therefore has been to supply those criteria which are established by investigations such as manufacturers seldom have the opportunity of prosecuting, and which, in face of the developments which are taking place in this industry, it is necessary they should both possess and apply.

The following table, compiled from Hugo Müller's *Pflanzenfaser,* is of interest as indicating the probable yields of fibre from different woods, by comparison of the yield obtained by the soda process :—

	Water.	Water Extract.	Resin.	Incrusting Matter.	Cellulose.	Pulp. Watt and Burgess' Process.
Birch, . .	12·48	2·65	1·14	28·21	55·52	40·00 per cent.
Pine, . .	12·87	4·05	1·63	28·18	53·27	34·70 ,,
Oak, . . .	13·12	12·20	0·91	34·30	39·47	20·60 ,,
Chestnut, .	12·03	5·41	1·10	28·82	52·64	25·10 ,,

In the course of this report we have said but little on the important point of the comparison of the cellulosic products of the various processes with one another ; but although they are not directly stated, the grounds upon which we regard the modern bisulphite processes as superior in this respect to the older alkaline methods are clearly implied.

It is a matter of common knowledge that cellulose, even in its more stable forms, is attacked by hot solutions of the caustic alkalies, and is more or less profoundly modified according to the strength of the solution and the temperature to which it is raised ; and we may reason *a fortiori* of wood cellulose, because, as already stated, it resembles rather the oxy-celluloses than the true celluloses.

On the other hand, we have exposed jute cellulose, which, as already explained, is of the same nature as that obtained from wood, to the conditions which obtain in the Ekman process without its undergoing sensible loss of weight; and further, we have determined the cellulose in freshly-cut grasses, in which it is but imperfectly elaborated, and therefore very susceptible of modification, both before and after exposure to these conditions, and the percentage obtained was the same in each case.

There is therefore no doubt that in the bisulphite processes even the structurally delicate forms of cellulose are conserved. The influence of this upon the yield of cellulose is of course very marked, the yield (of bleached pulp) by the soda process, from white pine, being approximately 33 per cent., whereas by the Ekman process it is from 45 to 50 per cent.

It is important to remember that this increased yield of cellulose cannot fail to affect the quality, and therefore the paper-making properties of the pulp. Those papers already in the market, composed entirely of wood-pulp (bisulphite) have a strongly marked individuality, being particularly distinguished by their hardness and transparency. Moreover their hygrometric properties are very different from those of ordinary papers—so much so, that it has been found necessary in printing upon them to adopt the dry method. Some discrimination must therefore be exercised in the use of wood-pulp for admixture with other fibres.

In regard to the bleaching of the pulp, it will be found that some practical experience is required for the control of the operation so as to produce uniform results. Precautions which have more particularly to be observed are—(1) the complete removal of the sulphites from the pulp before adding the bleaching liquor, which would otherwise be ineffectively consumed ; (2) the avoidance, in the washing, of waters containing iron as an impurity, the compounds of this metal reacting with certain constituents of the pulp to form dark-coloured bodies ; (3) a due regard to the composition of the bleaching solution, particularly the proportion of base, and the reaction of the pulp in the several stages of bleaching and preparing, bearing in mind that the presence of bases (alkaline reaction) favours the absorption of oxygen and the discoloration of the pulp.

It is impossible to give directions which will meet all the varied cases that may arise, both in the pulping process and the after manipulation of the pulp. Manufacturers should regard as a very necessary part of the equipment for the task of directing these operations the knowledge which comes from a study of the chemistry of the vegetable fibres; and this study we strongly recommend to all who have the opportunity, and who have not yet recognised the advantages which would accrue from realising it. A like consideration prevents our attempting to give special instructions for detecting the presence of wood-pulp in papers. Presuming that in the processes of pulping and bleaching the wood has been entirely deprived of those "non-cellulose" constituents which impart to it the properties, both chemical and morphological, which distinguish it in the raw or natural state, it is interesting to inquire what are the residual characteristics by which it may be identified, and can the identification be pushed to the extent of ascertaining the process by which the cellulose has been isolated? For such an investigation the first method to be employed is that of microscopic examination. This will readily reveal the presence of the wood fibre, and a careful inspection, aided by a comparative examination of standard specimens, will furnish such information as to the kind and degree of disintegration as will throw some light on the question of the treatment to which the wood had been subjected.

Of distinctive chemical reactions for the various celluloses we have as yet but few, and such as have been observed are, as might be expected, indicative of classes rather than of individuals. The only one we would mention here is the development of a rose-pink colour on boiling with a solution of aniline sulphate: this appears to be characteristic of the celluloses, isolated by means of the soda process. Wood-pulp from the bisulphite processes gives, when similarly treated, only a slight greenish yellow coloration, probably resulting from residual traces of lignose. Those who wish for more complete information on these points must consult the literature of the subject.

LIST OF ENGLISH PATENTS BEARING UPON THE TREATMENT OF WOOD FOR THE PREPARATION OF WOOD-PULP, ETC.

	No.		
1855.	1418.	Jullion.	Heating under pressure with sulphides.
1857.	234.	Hook.	,, ,, ,,
1866.	2924.	Tilghmann.	Heating under pressure with sulphurous acid, with or without a base.

	No.		
1867.	385.	Tilghmann.	Heating at ordinary atmospheric pressure with sulphurous acid, with or without a base.
1874.	2939.	Mitscherlich.	Heating under pressure with bi-sulphite of lime.
1880.	4984.	Cross.	Heating under pressure with basic solutions of sodium sulphite (in iron vessels).
1881.	3062.	Ekman.	Heating under pressure with solution of magnesium bi-sulphite.
1881.	4419.	Francke.	Heating under pressure with solution of calcium bi-sulphite.
1882.	581.	Ekman.	Heating under pressure with solutions of magnesium or sodium sulphites or bi-sulphites.
1882.	5365.	Graham.	Heating under pressure with solution of calcium bi-sulphite.
1883.	3240.	Blitz.	Heating under pressure with solution of sodium sulphide, together with ammonium vanadate.
1884.	2701.	Dahl.	Heating under pressure with a solution containing the sulphate, sulphide, hydrate, and carbonate of sodium.
1884.	9509.	Pictet.	Heating under pressure with aqueous sulphurous acid (10 per cent.) at temperatures below 100° C.

1881.	5532.	Francke.	Production of calcium bi-sulphite.
1882.	3714.	Pictet.	Production of anhydrous sulphurous acid.
1883.	1349.	M'Dougall.	Production of calcium bi-sulphite.

1881.	5367.	Graham.	Coating iron with lead.
1883.	3257.	M'Dougall.	,, ,,

1883.	1549.	Cross and Bevan.	Preparation of sizing materials from bye-products of bi-sulphite processes.

XXI.

LACQUER (*URUSHI*).

DESCRIPTION, CULTIVATION, AND TREATMENT OF THE TREE, THE CHEMISTRY OF ITS JUICE, AND ITS INDUSTRIAL APPLICATIONS.

By Hikorokuro Yoshida,
Chemist to the Imperial Geological Survey of Japan.

The purpose of the following Essay on Lacquer is to bring before the Exhibition some idea of the remarkable properties possessed by the lacquer tree and its juice, and also to present the results of my recent chemical investigations, which till now have remained unpublished. The part of the paper which refers to the use of the juice in application to art has been compiled from the scattered literature of the subject, and also from my personal observations and inquiries in the districts where the lacquer industry is most largely engaged in.

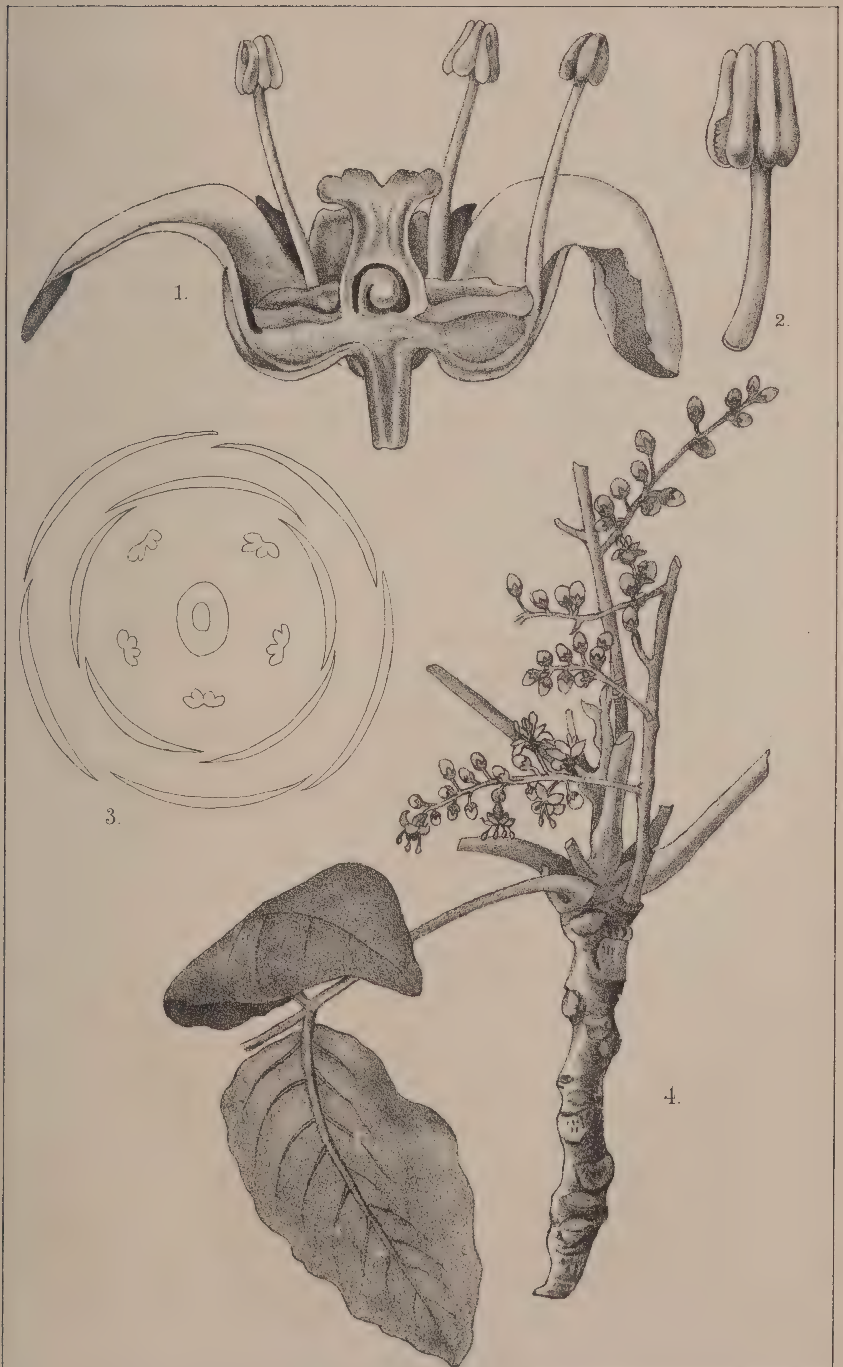
THE LACQUER TREE.

The lacquer tree, *Rhus vernicifera*, is indigenous to Japan. In appearance it resembles very much our ordinary wax-tree, having a nearly straight stem crowned with spreading branches. The flowers, which are of a yellow colour, appear in June, and the drupes ripen in October. The leaves are alternate, and five to six paired, with light-haired petiole. The leaflets, which become beautifully red in autumn, are either ovate, acuminate, or entire, and are glabrous above and pubescent beneath. The superior leaflets are subsessile; the inferior shortly petiolate; whilst underneath them cottony hairs are met with in greater or less abundance. The leaflets measure from two to four inches in length, and one inch and a quarter to two inches in breadth. The flowers, which are small, are polygamous, with small five-parted persistent calyx. The calyx lobes are imbricate and equal. The petals, which are five in number and of equal size, are oblong, spreading, and imbricated. The stamens are five in number, and appear at the base of the annular disc; the filaments are flattened and pointed at the end. The anthers in female flowers are abortive, and the ovary, which is either ovoid or globular, is sessile. The styles are short, and three in number. Plate VII. represents the flower and leaf of the lacquer tree. The drupes, which form in pendulous panicles, are flattened in shape, and about one-third of an inch broad and quarter of an inch long. They are nearly dry, and contain a one-seeded bony stone, in which the waxy matter is found. The height of an old tree is from twenty-five to thirty feet. At the thickest part the diameter of the stem is from eighteen inches to two feet. The wood is fine-grained, of a golden yellow colour at the centre, and it has a smooth greyish bark, which, when cut, discharges the lacquer juice.

The lacquer tree furnishes a fine timber, and supplies the famous juice and wax; for the sake of the two last-named substances it is extensively cultivated all over the Empire, but especially in the northern and middle provinces of the main island between latitudes 33° and 37°, at such places as Dewa, Aizu, Yamato, Yechizen, Hiroshima, and the neighbourhood of Tokio. The most important of these places are Yoshino in Yamato, and Aizu.

The tree is raised both from seeds and cuttings. That which is grown from the former is said to be longer-lived, whilst that raised from cuttings grows more quickly. Before sowing, the seeds are partially crushed, and soaked in water for some months. Those which sink are collected, and after being treated with wood-ashes to remove the waxy matter, are again put into the water-pit. Some farmers use horses' urine for steeping the seeds; this helps to remove the wax, and shortens the time of the second soaking to about thirty days. The seeds are taken out of the pit either in spring or autumn, and after being dried in the sun, they are planted in holes about three inches deep, and well watered. Germination

Pl. VII.



THE LACQUER TREE.

Fig. 1. Section of Flower of the Lacquer Tree. *(Rhus vernicifera.)*
Fig. 2. Stamen showing dehiscence. Fig. 3. Diagram of the Flower.
Fig. 4. Leaf and Inflorescence of the Lacquer Tree.

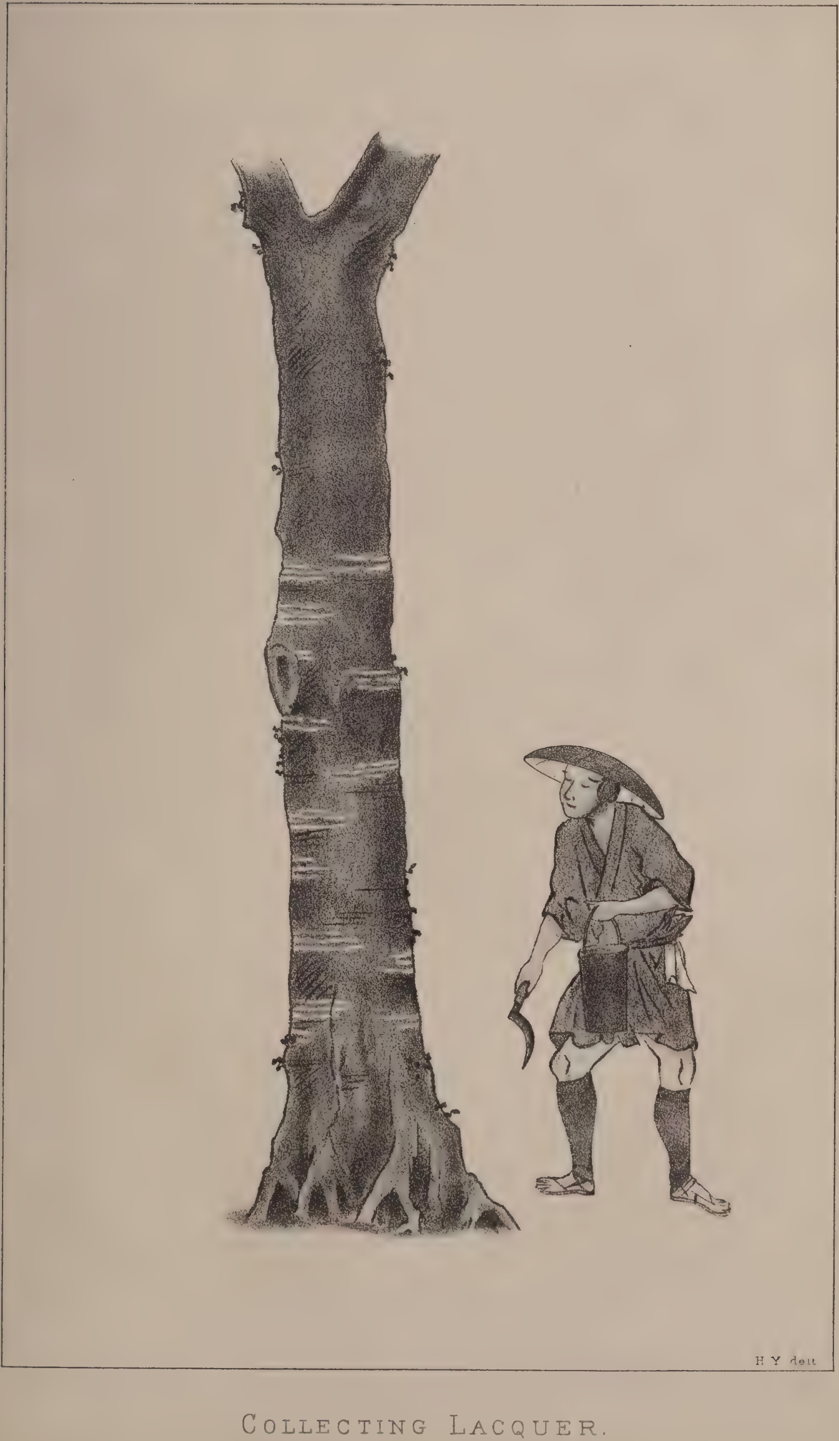
begins after twelve or thirteen days, and in order to protect the young shoots from the action of wind and rain, the earth is heaped around them to a height of three inches. When the young shoots acquire sufficient strength they are separated from one another, and transferred to convenient ground. At the end of the third year, the seedlings, being about three feet high, are again removed, and distributed so that an acre of land may contain about 1200.

In order to raise trees from cuttings, healthy roots are selected, and cut to the length of a foot, after which they are placed in carefully prepared ground, so that the roots project about two inches above the soil. When young shoots appear they are at once protected against the influence of bad weather, as previously described; but in this case, on account of the growth being more rapid, they are fit for final distribution and planting by the end of the second year. The most suitable soil is light clay loam with a slight admixture of coarse gravel. The place ought to be open towards the south-west, so that the sun's rays may fall freely upon it. Planting beside the sea-coast is said to quicken the growth; but it appears that the farmers usually allot to them those pieces of land, whether plain, valley, or hill, which are unfit for vegetable or corn-fields; and even in this case no manure is applied to the trees, the only attention given being to clear the weeds from them when they are very yonng.

When the tree is seven or eight years old it begins to bear fruit and yield juice; after the lapse of fifteen years the yield greatly increases; and up to thirty years of age the tree is considered to be in the highest state of activity. After this the amount of sap gradually diminishes; and the tree is either kept for the sake of its fruit, or it is cut down close to the roots, so as to reproduce young shoots, from which lacquer can be obtained in due time. Two kinds of juice can be extracted from the tree by different processes. They are distinguished as ordinary *Ki-urushi* and *Seshime-urushi.*

Ki-urushi, or raw lacquer, is the better of the two. It is collected from the middle of summer to the middle of November by the following process :—Shallow cuts are made on one side at the bottom of the stem, about an inch apart. The sap, which exudes in drops from between the outer and inner barks, is collected by a well-oiled hooked spatula into a bamboo tube. Another series of incisions is made on the other side of the stem about two feet higher up than the former ones, and this process of wounding the tree on alternate sides is continued as long as there is room. (See Plate VIII.) In the districts around Aizu the so-called "saving process" (*yo-jō-jaki*) is employed. By this process only so much sap is taken from the tree as will not injure its health, and it is frequently allowed to rest for a year between two successive sappings. By this sparing policy, the quantity of fruit is greatly increased, and the period of life of the tree is extended. In the lacquer grounds about Tokio the "killing process" is resorted to. No regard is paid to the yield of fruit, and the juice is extracted from young trees. This is repeated every year, and as large a quantity of juice as possible is obtained by making incisions very close together in the stem. The tree, when thus treated, never lasts longer than fifteen years: the quantity of fruit also becomes very small; and no profit can be derived from the wax. The yield of *ki-urushi* from a single tree per year, when the saving process is employed, is in the very best class of trees about 700 grammes; in the middle class, 350 grammes; and in the poorest about 240; the average being 400 grammes per tree. The quantity and quality of the juice depend upon the age of the tree and the season at which it is sapped. The largest quantity of the best quality is obtained from trees of twenty to twenty-five years of age, whilst younger trees yield a smaller quantity, the quality also being inferior, as it contains much gum and water. In the same tree the juice got during autumn is superior to what is obtained during the latter part of summer or the beginning of winter. By employing the killing process about 30 per cent. more of the juice is secured, giving an annual average yield of 530 grammes per tree.

Branches and twigs, which are cut from time to time, when steeped in water and then warmed at the fire, yield an inferior kind of juice. This is called *seshime-urushi*. When mixed with drying oil it is generally used as an under varnish. As lacquer juice is expensive, it is very rarely that *ki-urushi*



COLLECTING LACQUER.

comes to the market in a genuine form. It is usually mixed with more or less of the inferior *seshime* juice. In the hands of varnish-makers some of the oil of *Perilla ocimoides* (*yeno-abura*) is added to the already mixed juice, and even this, if excess be avoided, does not much impair the drying power of *urushi.*

The wax is prepared from the ripened fruit of the tree. The fruit is first thoroughly crushed in a stone mortar, then steamed or boiled in water for a short time, and finally squeezed in a powerful lever press. This wax is considered to be specially adapted for candle-making, as its melting-point is comparatively high. It brings a higher price than the common vegetable wax, which is here produced from the fruit of *Rhus succidanea* (*hajenoki*). The average yield of drupes per tree of twenty years of age is about half a bushel; and in one of forty years of age it increases to one bushel.

The wood of the lacquer tree is admired for its fine texture, grain, and colour, which is golden at the centre and white near the bark. In the north of Japan it is much used for making cabinets and other small articles; but no trees large enough for building are met with there.

The introduction of lacquer trees into Scotland, where, according to the account of the Geological Survey, the climate and the nature of some parts of the soil are both well fitted for its cultivation, would, I think, be a not unimportant service.

CHEMISTRY OF THE LACQUER JUICE.

Specimens of lacquer juice have been received from different parts of the country. That on which I worked was kindly supplied by Mr. Magaribuchi from Yoshino. As this juice was originally intended for chemical investigation, and as it was collected in the best place in the Empire, under strict official inspection, it must have been in the purest form obtainable.

The pure juice is a thick greyish fluid of dextrinous consistency, which, under the microscope, is found to consist of minute globules, of darker or lighter colour, mixed with small particles of opaque brownish matter, the whole being held mixed in the form of an intimate emulsion. It has a characteristic sweetish odour. The specific gravity is 1·0020 (20° C.); but some specimens, such as that obtained from Hachiôji, contained bark, dust, and other impurities, which raised the specific gravity to 1·038. If the juice be exposed to the air in a thin layer at 20° C. it rapidly darkens in colour, and dries up to a lustrous translucent varnish.

Mr. S. Ishimatsu (now S. Hiraga), in a paper on *Urushi*, which was written some years ago at Tokio University, and afterwards communicated to the Manchester Literary and Philosophical Society[1] by Professor Roscoe (Feb. 18th, 1879), has shown that the constituents of the juice are a resin, a gum, water, and a small residue insoluble in water or in alcohol. The method of separation which I employed was the same as that adopted by Mr. Hiraga. A resinous acid (urushic acid), together with a small quantity of the volatile matter, is separated from the other substances of the juice by treating it with absolute alcohol, evaporating the solution, and drying the acid at 105° to 110° C. The residue is boiled for some time with water, and the extract evaporated on a water-bath until it acquires a constant weight. This gives the quantity of gum. The residue, from the water extract, consisting of a coagulated diastatic matter, with small quantities of insoluble colouring substances, is dried at 100° C., and weighed. The difference of the sum of the percentages from 100 gives the amount of water and volatile matter. Thus pure Yoshino lacquer was found to have the following composition:—

	I.	
Part soluble in alcohol (urushic acid), . .	85·15	per cent.
Gum arabic, ...	3·15	,,
Residue (nitrogenous matter), . . .	2·28	,,
Water and volatile matter, ...	9·42	,,
	100·00	

The other unadulterated samples of the juice, some of which were analysed by Mr. J. Takayama in our laboratory, had the following composition:—

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[1] Memoirs, Manchester Literary and Philosophical Society, 3d series, vol. vii. p. 249.

	II. Hotta-mura Hitachi.	III. Sagami (southern district).	IV. Yechigo (northern district).	V. Hachiōji Sagami.	VI. Origin unknown. Bought at Tokio.	VII.[1] Origin unknown. Bought at Tokio.
Urushic acid,	64·62	68·83	66·92	80·00	64·07	58·24
Gum arabic,	5·56	5·02	4·75	4·69	6·05	6·32
Nitrogenous matter,	2·10	2 01	1·72	3·31	3·43	2·27
Oil,	0·09	0·06	0·06	?	0·23	?
Water and volatile matter,	27·63	24·08	26·55	12·00	26·22	33·17
	100·00	100·00	100·00	100·00	100·00	100·00

The juice which contains the largest amount of urushic acid is considered the best; in this respect No. I. Yoshino sample is superior to the rest, whilst VI. and VII. represent the average quality of the juice found in commerce.

I. *Examination of the alcoholic extract, Urushic Acid.*—This peculiar acid is the main constituent of the original juice, and also of the portion soluble in alcohol. The juice also contains a very small quantity of a volatile substance which passes into alcoholic solution, and is almost completely driven out during the drying of the acid at 105-110° C. Urushic acid is a pasty substance of somewhat dark colour, having the characteristic smell of the juice, readily soluble in benzene, ether, carbon bisulphide, and chloroform, less easily soluble in fusel oil and petroleum of high boiling-point. It is quite insoluble in water. Its specific gravity, taken at 23° C., is 0·9851. The acid is not affected by a temperature of 160° C., but above 200° C. it decomposes slowly with carbonisation. When exposed to the air or in oxygen gas it neither dries up nor shows any sign of change as the original juice does, and in other respects it is a very stable body. The acid possesses very poisonous properties, and produces a most disagreeable itching sensation when applied to the skin. Although it does not act with equal severity upon all persons, the attack is worst when one comes in contact with it for the first time, subsequently the effect of the poison is very little felt. An immediate application of strong solution of acetate of lead to the inflamed part is the most effective remedy.

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[1] Analysed by Mr. Hiraga.

The acid, dried at 110° C., and analysed, gave the following results :—

	I.	II.	Mean.	Theory for $C_{14}H_{18}O_2$ demands
Carbon, . .	77·09	77·01	77·05	77·06
Hydrogen, .	9·28	8·75	9·01	8·28
Oxygen, . .	13·63	14·24	13·94	14·66
	100·00	100·00	100·00	100·00

From its alcoholic solution many metallic salts can be produced, most of which are slightly soluble in alcohol, but almost insoluble in water. *Silver nitrate* gives at first a fine dark precipitate, slightly soluble in alcohol; on boiling, silver is reduced, with deposition of a mirror on the sides of the vessel. *Platinic chloride* and *uranium acetate* give fine dark brown precipitates. *Copper nitrate* imparts a black colour to the alcoholic solution; if it be diluted with water the copper compound separates out in a finely divided state. *Lead acetate* gives a greyish flocculent precipitate—a very characteristic reaction of the acid. A quantity of this compound was prepared by precipitating an alcoholic solution of the acid with the lead salt. The precipitate, after being partially dried over a water-bath and in a desiccator, was analysed, and the results were as follows :—

	Found.	Theory for $(C_{14}H_{17}O_2)_2Pb$ requires
Carbon, ...	52·08	52·40
Hydrogen, ...	5·34	5·30
Oxygen, ...	10·13	10·01
Lead, ...	32·45	32·29
	100·00	100·00

This lead compound is a somewhat unstable body; when heated in an air-bath to 100° C. it gives off a peculiar odour, and turns darker in colour; at 110° to 115° C. it melts and becomes a dark-brown mass; at about 130° C. it ignites spontaneously in the air, burning with a smoky flame, and leaving an oxide of lead.

Another salt of this acid which I examined was an iron compound. *Ferric chloride* gives a deep black voluminous precipitate, very slightly soluble in alcohol, and almost insoluble in water. Some of the alcoholic solution was precipitated with an insufficient amount of ferric chloride in order to see whether this fractional precipitation gave a salt of different composition. The compound obtained proved to be a salt of a very acid nature. Before analysis it was partially dried over a water-bath, and finally in a desiccator over sulphuric acid.

	I.	II.	Mean.	Theory requires for $(C_{14}H_{17}O_2)_3Fe$ + $9\ C_{14}H_{18}O_2+2H_2O$.
Carbon, . . .	74·42	74·40	74·41	74·51
Hydrogen, . .	8·18	8·13	8·15	8·03
Iron, . . .	2·07	2·07	2·07	2·08
Oxygen, . . .	15·33	15·40	15·37	15·38
	100·00	100·00	100·00	100·00

Another preparation of the iron salt was made with a larger quantity of ferric chloride than before. The compound again proved to be an acid salt, but of less complexity than the first. On analysis it gave the following result :—

	Found.	Theory for $(C_{14}H_{17}O_2)_3Fe$ $+3\ C_{14}H_{18}O_2$ requires
Carbon, ...	74·56	74·06
Hydrogen, ...	8·06	7·72
Iron, ...	4·29	4·11
Oxygen, ...	13·09	14·11
	100·00	100·00

These salts have very similar characteristics. They are light substances of a faint peculiar odour; at 120° C. they melt to a black mass with some decomposition, and at a somewhat higher temperature they ignite spontaneously, giving off dense smoke of a disagreeable odour. The *roiro* lacquer is produced by the formation of some of these iron compounds.

As iron urushiate is an unstable body, very prone to oxidation, I made an experiment to find the nature and extent of the change it undergoes when heated to 105° C. in a current of dry oxygen gas. An alcoholic solution of urushic acid was precipitated with a solution of ferric chloride; the precipitate was collected, washed, and heated on a water-bath. The dry salt, before the experiment, had the following composition :—

	I.	II.	Mean.
Carbon, ...	71·41	71·52	71·47[1]
Hydrogen, . . .	7·68	7·66	7·67
Iron, ...	2·30	...	2·30
Oxygen, ...	18·61	...	18·56
	100·00		100·00

Ratio of atoms in the formula brought out by this analysis:— C : H = 14 : 18·03. C : O = 14 : 2·73. Fe : C = 1 : 144·9. The substance was introduced into a tube and heated at 105° C. in an air-bath in a current of pure oxygen ; this was continued for thirty-six hours, till the weight of the substance became constant. The volatile products of the reaction were collected in a calcium chloride tube and potash bulb. The thermometer attached to the tube always showed 1°·5 or 2° C. higher temperature than that in the air-bath, especially during the first stage of the reaction. The following were the results :—

Sample taken = 2·6820 grammes.

Increase in weight of the substance after heating = 3·06 per cent. of substance.
,, ,, ,, calcium chloride tube = 7·69 ,, ,,
,, ,, ,, potash bulb = 5·75 ,, ,,

Oxygen taken up by the substance = 16·50 per cent. ,,

From this it appears that 41·4 per cent. of the quantity of oxygen used had gone to form water. The composition of the substance after oxidation was—

	I.	II	Mean.
Carbon, ...	66·58	66·85	66·72
Hydrogen, . . .	6·78	6·73	6·75
Iron, ...	2·26	...	2·26
Oxygen, . . .	24·38	...	24·27
	100·00		100·00

This gives the atomic ratios :—
C : H = 14 : 17·0. C : O = 14 : 3·82. Fe : C = 1 : 137·7.
Taking into account the increase in weight (3·06 per cent.) which the substance had acquired by oxidation, the quantities

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[1] The compound seems to have suffered some oxidation during its purification.

of carbon, hydrogen, and oxygen in the substance before and after oxidation are as follows:—

	Before oxidation.	After.	
Carbon, ...	71·47 per cent.	68·76 per cent.	2·71 decrease.
Hydrogen, . .	7·67 ,,	6·96 ,,	0·71 ,,
Oxygen, . . .	18·56 ,,	25·01 ,,	6·45 increase.
			3·03 increase.

Supposing the increase in weight in the calcium chloride tube to be mainly due to water, the corresponding amount of hydrogen calculated from it is 0·85 per cent. This nearly agrees with the decrease in the amount of hydrogen which the substance had suffered, viz. 0·71 per cent. The oxygen is then distributed thus:—

Taken up by the substance during heating	=	6·45 per cent.
In the water formed . . .	=	6·84 ,,
In carbonic acid and volatile matters .	=	3·21 ,,
		16·50 per cent.

3·21 parts of oxygen require 1·20 parts of carbon to form carbonic acid (CO_2). There remains therefore 1·51 per cent. of carbon unaccounted for, which shows that the carbon partially goes away as a volatile substance, not carbonic acid. This is very probably the case, as the potash lye, through which the escaping gases were conducted, was coloured reddish brown. On account of the amount being too small to admit of analysis, it cannot be known at present whether this volatile organic substance also contains hydrogen, nor what is its exact nature.

The experiment goes to show that in preparing a good *roiro* lacquer, one must be careful to avoid adding too much iron salt to the juice; for in that case the varnish will, in course of time, acquire a much browner shade (the oxidised iron urushiate having a reddish brown colour), losing at the same time in some measure its admirable qualities of resisting the action of strong chemical reagents. A small quantity of any soluble iron salt added to the juice will suffice for the preparation of the best *roiro* lacquer.

Free alkalies impart a very dark colour to the solution of urushic acid, which by transmitted light looks purplish blue, and by reflected light very dark brown. This viscid compound, if exposed to the air, rapidly blackens and dries up. It is a compound of an alkali metal with the acid, the normal salt of which will probably be represented by the formula $C_{14}H_{17}M'O_2$. The salt was not quite fit for analysis, as it seemed to suffer oxidation like some other salts of urushic acid during the processes of purification and drying. It is soluble in a rather large quantity of ether or benzene, and less easily in alcohol; the solution in light petroleum oil gives a lustrous varnish which dries up very easily. Weak sulphuric acid apparently produces no change in this black compound, but when boiled with strong hydrochloric acid it is converted into an elastic gum-like substance, a polymerised body. The analysis of this substance shows that it contains a little hygroscopic water; thus:—

	Found.	Theory for $2\ C_{14}H_{18}O_2 + H_2O$ require
Carbon, ...	73·97	74·01
Hydrogen, ...	8·51	8·37
Oxygen, ...	17·52	17·62
	100·00	100·00

Long-continued action of strong hydrochloric acid upon urushic acid produces a peculiar change in the latter; the resulting body has exactly the same composition as the original acid, but very different properties. When urushic acid was heated with a very large excess of hydrochloric acid for about three days, that lost by evaporation being replaced, it first swelled up to a soft sponge, gradually assumed a caoutchouc-like state, and finally hardened into a dark inadhesive mass. The substance, being cut into small pieces, was boiled with water, filtered,[1] and dried over a water-bath till the last trace of hydrochloric acid retained in the pores of the substance was expelled. On cohobation with alcohol a small quantity of the substance dissolved, and this, when examined, showed the usual characteristics of unchanged urushic acid. The residue dried at 105° C., gave this result on analysis:—

	Found.	Mean obtained for Urushic Acid.
Carbon, ...	77·07	77·05
Hydrogen, . . .	8·77	9·01
Oxygen, . . .	14·16	13·94
	100·00	100·00

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[1] The filtrate left no residue on evaporation.

It appears from this that urushic acid suffers molecular transformation (polymerisation) under the influence of strong hydrochloric acid. β-urushic acid thus formed is a dark brownish solid body with a faint peculiar odour, and soluble with difficulty in the usual solvents of urushic acid. Such being the case, an experiment was tried to ascertain whether urushic acid dries in an atmosphere charged with hydrochloric acid. A glass plate very thinly coated with pure urushic acid was placed upon a basin containing fuming hydrochloric acid under a bell jar: it dried after standing two days. The urushic acid darkened in colour, and looked somewhat similar to the naturally hardened lacquer. When the β-acid is heated to 100° C. it merely softens a little, and even at 130° it shows no sign of decomposition. It appears that the substance obtained by the decomposition of an alkali salt of urushic acid with hydrochloric acid is the same body as β-urushic acid.

Bromine acts powerfully upon urushic acid, evolving fumes of hydrobromic acid. To a solution of the acid in carbon bisulphide bromine was gradually added till it was in some excess; the whole being evaporated to dryness over a water-bath, the mass was exhausted with strong alcohol, and the extract again evaporated, after which it yielded a dark semi-solid mass. This was tested for bromine by igniting it with pure lime. 0·7060 grammes of the substance gave 1·1510 grammes of silver bromide; or bromine was shown to be present in amount equal to 69·37 per cent., agreeing with a hexabromo substitution derivative of the acid, $C_{14}H_{12}Br_6O_2$, which would contain 69·36 per cent. of bromine. At ordinary temperatures it is an almost solid body of a brownish colour, and soluble in most solvents of urushic acid. By using regulated quantities of bromine its lower substitution products might perhaps be obtained. Chlorine also gives a series of substitution products; but the compounds have not yet been fully examined.

The action of *nitric acid* upon urushic acid gives rise first to a series of nitro-substitution products which appear to change afterwards into another acid containing more oxygen. The reaction is very energetic; the urushic acid first swells up to about thirty times its original bulk in the form of a yellowish sponge, which disappears gradually with the progress of the reaction. A quantity of this porous body was heated for half a day, treated with a large quantity of water, dissolved in alcohol, and precipitated with ferric chloride. The precipitate, after the usual purification and drying, was analysed, and the following results obtained :—

	Found.	Theory for $[C_{14}H_{15}(NO_2)_2O_2]_3Fe$ needs
Carbon, . . .	51·49	51·59
Hydrogen, . . .	4·82	4·61
NO_2.	28·16	28·25
Iron, ...	9·77	9·81
Oxygen, . . .	5·76	5·74
	100·00	100·00

This is the ferric salt of *di-nitro-urushic acid.* The acid itself is a bright yellowish solid, readily soluble in the usual solvents of urushic acid, and gives characteristic reactions with many metallic salts : those of silver, lead, zinc, and manganese are light yellowish precipitates; those of copper and iron, greenish yellow ; and those of soda and potash, light brownish. The acid itself and its metallic salts are to some extent soluble in water, and more so in alcohol. The higher nitro-substitution products are likewise yellowish substances ; their salts also seem to be characterised by their greater solubility in water and alcohol.

When the action of nitric acid upon the yellowish substance is continued for several days, it finally goes into solution with copious evolution of nitrous fumes. On evaporating the solution over a water-bath, and cooling it, a large number of small granular crystals separate. The mother liquor, when treated with more of the strong nitric acid and evaporated, yielded several crops of similar crystals. These crystals were mixed, cleaned from the small quantity of brownish oily matter, and re-crystallised from ether several times until quite pure. On analysis the following result was obtained :—

	I.	II.	III.	Mean.	Required by theory for $C_{13}H_{22}O_8$.
Carbon, . .	50·96	50·82	51·01	50·93	50·98
Hydrogen, .	7·13	7·20	7·22	7·18	7·19
Oxygen, . .	41·91	41·98	41·77	41·89	41·83
	100·00	100·00	100·00	100·00	100·00

The substance is an acid which contains no nitrogen, and no water of crystallisation. At 134° C. it melts without decomposition to a yellowish liquid, and at 126° C. solidifies in a capillary tube. It is readily soluble in alcohol and water, and less easily in ether. Its iron and lead salts are yellowish crystalline precipitates; that of barium is straw yellow, and of silver white. They are all slightly soluble in water. The alkali and calcium salts, which are also light yellow, are readily soluble in water and in alcohol. A quantity of the silver salt of this body was prepared by decomposing silver acetate with aqueous solution of the acid. The ensuing precipitate was analysed with the following result :—

	I.	II.	Mean.	Theory for $C_{13}H_{18}Ag_4O_8$ needs
Carbon, . . .	21·20	21·19	21·20	21·25
Hydrogen, . .	2·39	2·59	2·49	2·45
Silver, . . .	58·86	58·86	58·86	58·85
Oxygen, . . .	17·55	17·36	17·45	17·45
	100·00	100·00	100·00	100·00

This silver salt suffers partial decomposition, blackening when exposed to sunlight. The barium salt of this acid was prepared by exactly neutralising its aqueous solution with barium carbonate. The solution was evaporated to dryness, and the substance obtained analysed. By carefully and slowly evaporating the aqueous solution of either the silver or the barium salt, the substance can be got in minute hard crystals.

	Found.	Theory for $C_{13}H_{18}Ba_2O_8$ requires
Carbon, ...	27·02	27·08
Hydrogen, ...	3·09	3·13
Barium, ...	47·60	47·57
Oxygen, ...	22·29	22·22
	100·00	100·00

From the analyses of its salts the acid is evidently a new one, and tetrabasic, being represented by the formula $C_9H_{18}(COOH)_4$; but no name has yet been given to it.

The distillation of urushic acid with lime gives a small quantity of light hydrocarbon, which, however, appears to polymerise very easily during its purification by fractional distillation. The nature of this oil is being examined; but one of the lighter fractions analysed gave numbers which indicate a composition approaching that represented by $C_{14}H_{24}$, showing it to be probably one of the higher hydrocarbons of the terpene series. It absorbs oxygen from the air, and forms a resinous mass. It unites readily with bromine, and is blackened by concentrated sulphuric acid in the cold.

II. *Examination of the water extract, the Gum.*—Gum is a normal constituent of lacquer juice, and forms from 3 to 8 per cent. of the original liquid. Since gum is insoluble in alcohol, it is conveniently separated by treating that portion of the original which was insoluble in alcohol with boiling water, filtering, and evaporating on a water-bath till the weight becomes constant. In this way a friable light-coloured, tasteless, and inodorous substance is obtained. This is the anhydrous gum. On combustion it gave the following numbers:—0·5267 grammes of the substance gave 0·7823 grammes of carbonic acid (CO_2), 0·2834 grammes water (H_2O), and 0·0267 grammes ash. Analysis of the ash in a separate sample of the substance gave the following:—

Silica (SiO_2),	0·48	
Lime (CaO),	44·77	
Potash (K_2O),	13·68	
Iron oxide,	trace.	
Alumina (Al_2O_3),	7·85	
Magnesia (MgO),	5·79	
Soda (Na_2O),	1·33	
Carbonic acid (CO_2),	26·10	by difference.
	100·00	

If the metals in the ash be replaced by the equivalent amount of hydrogen, and the result calculated for carbon, hydrogen, and oxygen, the result will be:—

	Found.	Arabic acid $C_{12}H_{22}O_{11}$.
Carbon,	42·47	42·11
Hydrogen,	6·40	6·43
Oxygen,	51·13	51·46

The gum, when inverted, has the power of reducing

Fehling's solution. 0·4747 grammes of the substance (ash deducted), after inversion with 10 per cent. hydrochloric acid, and precipitated, gave 0·8114 grammes of cupric oxide. If we suppose that after the hydration, one molecule of arabic acid ($C_{12}H_{22}O_{11}$) changes into two molecules of sugar ($C_6H_{12}O_6$), the molecular ratio which the product of inversion bears to cupric oxide will be exactly two-thirds of that of dextrose to cupric oxide, and consequently its cupric oxide reducing power or K will be 75. This, however, requires further confirmation. But whatever may be the nature of the sugar which is produced from this gum, its physical properties are identical with those of gum arabic. It is present in urushi juice in the form of an acid salt (probably of arabic acid), in combination chiefly with potash, lime, alumina, and magnesia; and the point of difference which is of interest is the presence of an alumina salt, which has not hitherto been observed in other gums. A mixture of the gum and urushic acid with water in the proportion in which they exist in the juice *does not undergo any change* even when exposed to the conditions most favourable for the drying of the lacquer. Moreover, part of the gum can be extracted in an unchanged state from the perfectly hardened lacquer, and since it exists in the original juice in the form of aqueous solution, it probably serves to keep the constituents of the juice in a state of uniform distribution and intimate emulsion. It may also act as a binding material, and assist the adhering power of the lacquer when laid on any surface.

III. *The Nitrogenous Matter and its action upon Urushic Acid.*—That portion of the juice which remains insoluble in alcohol and boiling water consists essentially of a nitrogenous matter, the action of which upon urushic acid is the cause of the hardening of the lacquer. It forms from 2 to 8 per cent. of the original juice. The juice which contains most of it dries most quickly, but gives a varnish with inferior lustre. The substance, separated from the gum by the usual method of boiling water, has no action upon urushic acid, but the residue (after the separation of urushic acid) or its extract with cold water, shows its peculiar diastatic activity in an unimpaired degree. When such a solution is boiled, the albuminoid matter coagulates in the form of a white precipitate.

The substance, first dried on a water-bath, and then over sulphuric acid, gave, on analysis, the following numbers:—

	I.	II.	Mean.
Carbon, . . .	59·52	59·72	59·62
Hydrogen, . . .	7·62	lost.	7·62
Nitrogen, . . .	5·48	...	5·48
Oxygen, . . .	26·18	...	26·08
Ash, ...	1·20	...	1·20
	100·00		100·00

In the ash traces of sulphur and phosphorus were detected.

The substance is slightly soluble in water, 10 per cent. sodium chloride solution, and in weak alkali solutions; but other liquids seem to have no solvent action upon it. It has no perceptible action upon sugar solution or gelatinised starch. It differs from the other albuminoids in containing a notably smaller amount of nitrogen (only one-third), whilst the numbers obtained for carbon, hydrogen, and oxygen for its composition very nearly agree with those of the other albuminoids. Active principles of malt (diastase), *koji* and saliva do not possess the same property of exerting the peculiar action above mentioned upon urushic acid.

Two series of experiments were instituted to test the activity of the nitrogenous matter upon urushic acid, first at different temperatures, and secondly in different gaseous media. For this purpose a small quantity of Yoshino juice was put into a covered beaker and subjected to the regulated heat of the water-bath, the water lost by evaporation being replaced. The heated juice was next thinly coated on a glass plate, and left to dry in a box, the air of which was kept constantly moist by the falling in of drops of water. The time of heating in each experiment was three and a half to four hours, and the temperature of the drying-box was 20° C.

1. At ordinary temperatures (20° C.) the sample dried after 3½ hours in air, and the same under a bell jar containing moist oxygen gas dried after less than 2 hours.

2. The juice heated to 30° C., sample dried after 4 hours.
3. „ „ 40°-43° C., „ „ 4½ „
4. „ „ 50° C., time not known.
5. „ „ 55°-59° C., „ after 24 hours the surface of the lacquer had a dull appearance.
6. The juice heated to 60°-63° C., sample did not dry.
7. „ „ 80° C., „ „
8. „ „ 100° C., „ „

Mr. J. Takayama, working very carefully on a sample bought at Tokio, found the limit of activity of the nitrogenous matter to be 70°-73° C., but with the Yoshino sample (which contains much less nitrogenous matter and water) he confirmed my former number of 60° C. as the limit. His method was to place the juice in a boat in a tube immersed in gradually heated water.

Next, glass plates coated with urushi juice were put under a bell jar containing an experimental gas, and left to dry at the temperature of the air, ranging between 13° and 15° C.

1. In dry air the sample did not dry.
2. „ moist „ „ dried after 4 hours.
3. „ dry oxygen „ did not dry.
4. „ moist „ „ dried after 2½ hours.
5. „ dry hydrogen „ did not dry.
6. „ moist „ „ dried imperfectly after 1½ days.
7. „ dry carbonic acid the sample did not dry.
8. „ moist „ „ dried very slowly after 2 days.
9. „ dry nitrogen „ did not dry.
10. „ moist „ „ dried imperfectly after 1½ days.

The legitimate inference to be drawn from all these experiments is that the combination of oxygen and moisture at the temperature of 20° C. is an essential condition for the display of the fullest activity of the diastatic matter, and consequently most favourable for the drying of the lacquer. With either the increase or decrease of temperature, the drying power decreases; at 0° to 2° C. it is temporarily suspended, and at from 60° to 70° C., the substance entirely loses its activity; this is then the point at which the coagulation of the albuminoid matter takes place, or, in other words, the diastatic action ceases. With other gases, however, I am inclined to think that some atmospheric air, which may have been present in them, might have favoured the conditions for drying; otherwise it would not have been possible. At least Mr. J. Takayama has recently confirmed the view that lacquer juice never dries in atmospheres of hydrogen or carbonic acid when kept in a eudiometer standing over mercury. These conclusions bear out the practical experiences of our lacquer men, viz., that lacquer dries most readily in the rainy season, and better in summer than in winter—a damp atmosphere at a temperature of 20° to 30° C. being usual during the rainy season.

The nitrogenous matter in the juice, if it be really possessed of a peculiar kind of diastatic action upon urushic acid, ought to be able to cause the change upon a comparatively large amount of the acid. To study this property, and to find out the limit of the quantity of that substance within which the action can still take place upon the acid, some experiments were made.[1] Various mixtures of a known quantity of Hachioji juice with a weighed quantity of pure urushic acid were made; after each mixture had received the requisite quantity of water, it was thoroughly mixed in a mortar, and left to dry in a thin layer on glass plates in a moist chamber. These mixtures and the original juice, free of water, had the following composition:—

	Mixture I. $\frac{\text{juice}}{\text{acid}}=\frac{1}{1{\cdot}3}$	II. $\frac{\text{juice}}{\text{acid}}=\frac{1}{4{\cdot}5}$	III. $\frac{\text{juice}}{\text{acid}}=\frac{1}{7{\cdot}7}$	Original juice.
Urushic acid, .	96·34	98 53	99·09	89·35
Gum, ...	2·64	1·08	0·67	7·68
Nitrogenous matter,	1·02	0·39	0·24	2·97
	100·00	100·00	100·00	100·00

The experiments showed that mixture I. dried after about

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[1] As this experiment was conducted in January, the temperature of the air favourable for the drying of the lacquer continued only seven or eight hours a day.

8 hours; II. took about 14 hours to dry; III. about 24. 0·24 of the nitrogenous matter to 99·09 of urushic acid was thus found to be the practical limit within which the action can take place. Although a much less quantity of the diastatic matter can effect the drying of the acid after the lapse of many days, such length of time will be considered unquestionably inconvenient in the practical working with the juice as a varnish. This experiment also shows that the amount of gum in the juice can be brought down to a small percentage. A large quantity of it, as it exists in bad juice, is always injurious, as it produces blisters upon the newly lacquered ware when it is brought into contact with water for any length of time. Knowing these facts, we are now able to prepare any good quality of the juice for varnish-making, by mixing a regulated quantity of pure urushic acid with the natural juice.

The question still remains, How does the diastase act upon the urushic acid, or what is the change which urushic acid undergoes in drying? To solve this question, the states of the lacquer before and after drying have been examined and compared.

A quantity of the fresh juice (Yoshino sample) was rapidly heated on a water-bath, so as to coagulate the albuminoid, and put a stop to its further action upon the urushic acid. The heat was continued till all the water was expelled from the juice; the substance was then analysed, with the following result:—

	I.	II.	Mean.	Numbers calculated from the constituents of the juice.
Carbon, . . .	75·47	75·61	75·54	75·54
Hydrogen, . .	8·93	9·01	8·97	9·14
Nitrogen, . .	0·11	...	0·11	0·10
Ash, . . .	0·21	...	0·21	0·21
Oxygen, . .	15·28	...	15·17	15·01
	100·00		100·00	100·00

The lacquer dried (naturally hardened) in the usual manner, and afterwards heated at 100° C. had the following composition :—

	I.	II.	Mean.
Carbon,	70·90	70·84	70·87
Hydrogen,	8·55	7·90	8·225
Nitrogen,	0·092	...	0·092
Ash,	0·032	...	0·032
Oxygen,	20·426	...	20·781
	100·000		100·000

The comparison of these two results indicates that the lacquer in hardening had taken up oxygen; and we see that, *cœteris paribus,* the amount of oxygen thus taken up is almost quite accounted for on the supposition that each molecule of urushic acid ($C_{14}H_{18}O_2$) in the juice has taken up one atom of oxygen, and changed into another body, $C_{14}H_{18}O_3$.

Further proof of this theory has been reached by the preparation of *oxy-urushic acid* ($C_{14}H_{18}O_3$), *which showed all the properties of a dried lacquer.* Urushic acid was repeatedly subjected to the action of strong chromic acid mixture, containing some excess of sulphuric acid to prevent the precipitation of chromic oxide. The product, cohobated with strong alcohol to dissolve away the urushic acid unacted on, gave on drying at 105° C. a brownish powder of the following composition:—

	First Preparation.		Second Preparation.	
	I.	II.	I.	II.
Carbon,	71·55	71·50	71·69	71·71
Hydrogen,	8·32	8·13	7·60	7·72
Oxygen,	20·13	20·37	20·71	20·57
	100·00	100·00	100·00	100·00

	Mean.	Theory for $C_{14}H_{18}O_3$ requires
Carbon,	71·61	71·79
Hydrogen,	7·94	7·69
Oxygen,	20·45	20·52
	100·00	100·00

This substance is very stable, and resists the action of strong mineral acids, except hot fuming nitric acid, which gradually changes it to a yellowish body, and finally into the new acid previously mentioned, $C_9H_{18}(COOH)_4$. No solvent has yet been found for it. *The strength and durability of lacquer varnish are due to the presence of this oxy-urushic acid.*

To establish more conclusively that the hardening of the lacquer is due to *oxidation* and *not hydration* of urushic acid, Mr. J. Takayama made the following experiments, and their results confirm the first view. Some pieces of glass coated with lacquer juice were introduced into a large combustion tube. A current of dried air, saturated with moisture by passing through a weighed U-tube containing pumice-stone soaked in water, was led over the juice till it hardened; the escaping volatile matters were collected in a series of weighed calcium chloride and soda-lime tubes. After the lacquer had hardened, all the hygroscopic moisture which surrounded it was expelled by heat (100° to 102°C.), aided by a current of perfectly dry air, again conducted through drying-tubes placed in front of the combustion tube. Knowing the weight and composition of the juice taken, and that of each of the separate tubes (a water tube, two calcium chloride tubes and one soda-lime tube), before and after the experiment, we can easily calculate the result, thus:—

	I.	II.
Weight of the juice taken .	= 0·5055 grm.	1·3278 grm.
Juice contained 27·61% of water	= 0·1395 ,,	0·3666 ,,
Water entering glass tube .	= 0·0220 ,,	0·0715 ,,
Total water . . .	= 0·1615 ,,	0·4381 ,,
Water which left the tube .	= 0·1583 ,,	0·4210 ,,
Water disappeared . .	= 0·0032 ,,	0·0171 ,,
Water lost from original, calculated in percentage of urushic acid .	= 0·98 per cent.	1·99 per cent.

If urushic acid hardens by hydration, one molecule of it $(C_{14}H_{18}O_2 = 218)$ would require one molecule of water $(H_2O = 18)$, or 8·26 per cent. of water; but in the present experiments, if we suppose that the water which disappeared combined with the urushic acid, their molecular ratio in the first experiment is represented by 8·4 molecules of the acid to 1 molecule of water; and in the second, 4·1 molecules of the acid to 1 molecule of water. Both of these are theoretically impossible, and the figures can only be accounted for by experimental error. From this experiment, and those previously cited, we may safely conclude that the phenomena of the hardening of lacquer can only be brought about by *oxidation* of urushic acid into oxy-urushic acid. The part which water plays within the juice, and during its hardening, is to keep the nitrogenous matter (and gum) in a state of solution, so that it can better act upon the urushic acid.

It was also attempted to determine the amount of volatile matter evolved by the juice during the process of hardening. The quantity found was too small to affect the general result. In the last two experiments mentioned the quantities were respectively 0·10 per cent. and 0·57 per cent. of the weights of the juice taken ; and in the third experiment, in which 1·5 grammes of the juice were dried in a current of oxygen gas, it was only 0·24 per cent. I am inclined to attribute this volatile matter to a small quantity of that substance originally contained in the juice, as well as to some quantity of carbonic acid gas produced by secondary reactions which occur within the juice during hardening.

In the beginning of this paper it was stated that some drying oil is added to the lacquer juice to make varnish. I have studied this point, to learn how far the introduction of the oil is admissible, without impairing the essential quality of the lacquer. It was ascertained that the addition of 10 to 15 per cent. of the drying oil to the juice does not hinder the hardening power of the lacquer, and 20 or 25 per cent. of the oil can be introduced without much bad effect. Such a mixture gives a varnish of greater transparency and spreading power than the pure juice itself, but its capability of withstanding strong chemical reagents is proportionally reduced.

The results arrived at may be summed up in the following statements :—

1. Lacquer juice consists essentially of four substances, viz., urushic acid, gum, water, and nitrogenous matter.

2. The main constituent, urushic acid, is a stable acid, capable of forming many well-defined salts and derivative compounds.

3. The gum is probably identical with gum arabic.

4. The nitrogenous matter has a composition allied to albumen, with much less nitrogen, and has a peculiar diastatic property.

5. The hardening of the juice is due to the oxidation of urushic acid ($C_{14}H_{18}O_2$) into oxy-urushic acid ($C_{14}H_{18}O_3$), which is effected by the aid of the nitrogenous matter in presence of oxygen and moisture.

6. The hardening can only take place within narrow limits of temperature, viz. between 0° to 2° C., on one side, and the temperature of the coagulation of the albuminoid (60° to 70° C.) on the other.

7. The gum is essential in keeping up the emulsion and uniform distribution of the constituents; but in the hardened lacquer it is injurious, causing blisters on newly lacquered ware when treated with water for a length of time.

8. Any quality can be conveniently given to the juice by the addition of pure urushic acid, which brings down the relative amounts of gum and nitrogenous matter. The lacquer becomes thus more transparent and gains in strength.

9. The mixture of 20 to 25 per cent. of drying oil with the juice does not much impair the essential quality of the lacquer.

APPLICATION OF THE LACQUER JUICE FOR THE MANUFACTURE OF VARIOUS LACQUER VARNISHES.

It is now probably impossible to ascertain when the lacquer industry commenced in our country, but the rough use of the juice must have been very early known, as it readily forms a beautiful varnish on any surface which may be near, when it flows from an accidental wound in the tree. The old records extant show that in 380 B.C., during the reign of the Emperor Koan, there was an Imperial Lacquer Department, the chief officer in which was a certain Mitsu-ne-no-sukune. Some time after the beginning of the Christian era a great impetus seems to have been given to the industry by the Government, and during the middle of the sixth century, in order to promote its cultivation, lacquered wares are said to have been received in lieu of taxes.

Almost from time immemorial, our old capital, Kioto, was the centre of the lacquer industry. There the old princes and nobles exhibited the greatest taste for lacquered wares, and thither large numbers of artisans repaired from all quarters of the country. There a great improvement in the mode of decorating lacquered wares with gold, silver, and mother-of-pearl, was introduced, and the place holds to the present time its ancient superiority unimpaired. At present the trade is carried on in almost all parts of the country.

There are no less than twenty-five varieties of lacquered wares, many of which are named after the places where they received their special style and finishings.

To be made a varnish, the lacquer juice is first strained through linen, to get rid of bark, dust, and other impurities. Afterwards it is thoroughly stirred in large shallow dishes, and placed in the sun for several days, to remove superfluous moisture. The refined juice is then mixed with various substances, such as oil, fine clay, body pigments, metallic dusts, etc., according to the ware for which it is intended. The principal receipts are the following :—

1. *Roiro, or black lacquer.*—This is prepared by adding a solution of crude ferric acetate (*ohaguro*, tooth-dye), or the impalpable powder which is produced by the grinding of iron instruments on a whetstone. The mixture is thoroughly stirred in the sun for two or three days, till it acquires the proper consistency and a very fine black colour. Such a colour is caused by the combination of iron with some of the urushic acid in the juice. Excess of the iron compound must be carefully avoided ; a small amount produces the best black.

2. *Shuiro, or red lacquer.*—This is made by mixing about 20 per cent. or more of cinnabar powder (mercuric sulphide) with *ki-urushi*, with the aid of a little oil. The mixture is thoroughly beaten in a mortar and strained through thin unsized paper called *yoshinogami*. If the quantity of cinnabar be reduced, a much browner varnish will be obtained. It may be remarked, once for all, that urushic acid is not capable of decomposing most of the sulphides of the heavy metals. For this reason the colour of red lacquer varnish is not due to combination of the mercury with some urushic acid in the juice; the cinnabar acts merely as a body pigment within the mix-

ture. The same reason applies to the formation of yellow and green varnishes.

3. *Nakanuri, or varnish for middle coating.*—This is just the ordinary juice, from which the water is expelled by long stirring in the air. It is of a dark colour, and is applied to the ware mainly to gain the strength of the priming coat.

4. *Nuritate, or the varnish for under coating,* is made from a mixture of the juice with whetstone dust in water, to which is afterwards added a small amount of powdered turpentine. *Jōhana,* another variety of this substance, contains, besides the above-mentioned ingredients, some of the oil; it is well stirred in the light before use.

5. *Transparent lacquer* is prepared from the very best juice —which contains very small quantities of gum and nitrogenous matter—by dilution with 20 per cent. or more of the oil from *Perilla ocimoides.* It is applied as a final coat, and in a very thin layer for any work where transparency is needed. This varnish is extensively employed in the manufacture of *Suruga* ware, in which the beautiful grain of the wood is distinctly seen under the varnish.

6. *Makíye, or gold and silver lacquers,* are made by mixing about 30 per cent. or more of metallic powder in the finest state of division with a good juice. In good wares it is applied in a raised form in giving any designs, and, when subsequently polished, exhibits the appropriate lustre of the metal.

7. *Green and yellow lacquers.*—Different shades are made just like the red lacquer, only realgar and orpiment (sulphides of arsenic) are used instead of cinnabar. By varying the proportions of these pigments different shades of either green or yellow can be obtained. There are many other receipts for the preparation of different coloured lacquers. Modifications in the mode of preparing the varnish are always effected according to the shade of the colour which it is intended to have.

It has hitherto been impossible to produce blue, purple, or white with the lacquer, simply because the colour of the hardened pure lacquer being deep brown does not admit of the introduction of any such pigments with proper effect.

The process of applying the lacquer to any article is very laborious, and requires an experienced hand. We shall give a few details of the process. Some of the descriptions are taken from Mr. J. J. Quin's notes, with a few alterations and remarks.

Roiro, or black lacquering.—When cabinets or other articles to which the lacquer is to be applied have been made, and their surfaces smoothed, the wood is carefully cut away along each joining, so as to form an angular hollow. This is filled with small pieces of hempen cloth mixed with glue and paste (*kokuso*), and the whole surface is thinly coated with *seshime* lacquer. This process is called *kijí gatame*—hardening the wooden basis. A coating of wheat lacquer—lacquer mixed with an equal quantity of wheaten flour—is then given to the article over which the hempen cloth is stretched, great care being taken to lay it on smoothly, so as to leave no wrinkles or perceptible joinings. This hempen surface is then painted with a thin coat of *sabĭkô*, afterwards of *jinōko*, a paste made of water and finely-powdered earthenware biscuit; then a coating of *seshime* lacquer, followed by another one of *jinōko*, and again another of *seshime* lacquer. The article is then painted with *kiriko*—that is, a mixture of *seshime* lacquer and *jinōko*; after this it is ground smooth with a whetstone, and rubbed over with Japanese ink applied with cotton-wool. A coat of *nakanuri* (middle coating) then follows, and the whole surface is smoothed with charcoal made of the wood of *Magnolia hypoleuca* (*honoki*). A coat of the prepared *roiro* lacquer is then applied, after which it is rubbed over with a soft charcoal made of *Lagerstrœmia indica* (*hiyaku-jikkō*). Another coating of the same *roiro* lacquer is then carefully rubbed on with the finger, and the article afterwards receives a preliminary polishing with calcined deer's horn and whetstone finely powdered, which gives it a dull but smooth black surface, called *isuyakeshi*, or roughened surface. To make the surface of the ware perfectly smooth and shining, a coat of *seshime* lacquer is again given, then polished with the same kind of powder on a cotton cloth, and finally with the finger and a little oil, till it assumes a most brilliant polish.

Every article, after each application of a lacquer coat, must be kept in a large box or on a shelf, the inside boards of which are unplaned and thoroughly wet with water. The box is afterwards carefully closed to exclude the outer air until the lacquer is quite dry. During the cold months, when the prevailing temperature is unfavourable for the successful hardening of the lacquer, the room in which the drying-box stands must be warmed by a charcoal fire, to give the requisite temperature to the surrounding air. These precautions are necessary for the proper treatment of the lacquer.

2. *Shuiro, or red lacquering.*—The method is much the same as that of the black just described, in its earlier stages, but after rubbing the article with *Magnolia hypoleuca* charcoal a coating of red lacquer is given. The next process is to polish off the surface with cotton cloth and powder, the intervening processes from the rubbing with *Lagerstrœmia indica* charcoal being omitted. Red lacquer is much more easily managed than black, as it has a greater spreading power, and there is less danger of its blistering during drying.

The manner of making green and yellow lacquers is quite the same as that of making red lacquer, except that the final coat consists either of a green (lacquer mixed with realgar) or yellow lacquer (lacquer mixed with orpiment) previously prepared, as in the receipt No. 7.

All these methods are for the manufacture of the best wares. For the second-rate wares *minogami*, a very strong, unsized paper, is substituted for the hempen cloth. For the very inferior wares neither cloth nor paper is used, and the woods are only smeared with a peculiar astringent decoction of persimon fruits (*kakinoshibu*). The surface is next coated with *jinōko*, and is ground smooth only once before the final coat of the lacquer of the desired colour is added.

3. *Hiramakiye, or flat gold lacquer.*—The design to be transferred to the lacquer is drawn on a thin strong piece of paper, prepared with sizing of glue and alum. The article, having previously received the plain coats of lacquer, is covered with paper on which are the designs; on the reverse the outline of the design is traced with a lacquer, the diastatic matter of which was destroyed by heating. The parts where the lacquer has been applied are then carefully rubbed with a whalebone spatula. On removing the paper the design is seen lightly traced in lacquer. To make it perfectly plain, it is very lightly

rubbed with a piece of cotton-wool charged with whetstone powder or tin, which brings out the pattern white. From one tracing upwards of twenty impressions can be taken. When the lacquer is used up, only a fresh tracing is required over the same paper to reproduce the design *ad infinitum.* The pattern thus traced out is then filled in with groundwork lacquer, great care being taken not to touch the original tracing. It is then powdered over with fine gold dust, silver, or tin, according to the quality of the ware. This dust is applied with a piece of cotton-wool charged with the material to be used, and the article is then gently dusted with a very soft brush made from the long winter coat of a white horse, in order to remove any loose metal dust, and to smooth the surface slightly. If the article is large, only a small portion is done at a time, and it is at once enclosed in a drying-box, so as to prevent any dust adhering to the freshly lacquered surface. When it is sufficiently hardened it is taken out, and the part to which the gold dust was applied receives a coat of transparent lacquer laid on with a brush of hare's fur. These processes are continued on all parts of the ware where the design is intended. When the portion which has received the second coat over the gold dust is quite hard, it is rubbed smooth with a piece of hard camellia-wood charcoal, until the whole is nearly level with the surrounding parts. It is then rubbed by the finger with some oil and powdered deer's horn and whetstone till it attains a fine polish.

4. *Togidashi, or bringing out by polishing,* consists in the application of the design required to the plain lacquered article, in the same manner as in flat gold lacquering. The whole surface of the article then receives a coat of transparent lacquer, which, when dry, is ground down with charcoal made from the wood of *Chamæcyparis obtusa* (*hinoki*) till the pattern stands out. It is then polished out in the same manner with deer's horn and oil. Gold dust used for this purpose is a slightly coarser variety than that used for the flat gold lacquer.

5. *Takamakiye, or raised lacquer.*—The first and second processes are the same as when making the flat lacquer, but instead of gold dust finely powdered, camellia charcoal is sprinkled over the freshly lacquered surface. When dry the

article is carefully dusted with a soft cloth, to remove any loose powder, and the parts are further washed with a brush and water, to bring out the fine lines. Some good lacquer is then rubbed on the charcoal surface with a piece of cotton-wool, a coating of *sabikō* applied, and the article set to dry in a damp press. Afterwards the surface is ground smooth with *Magnolia hypoleuca* charcoal, and further rubbing is given with the powdered camellia-wood charcoal on a piece of cotton cloth. Some good lacquer is then applied as before, and after drying it is polished with oil and powder. Next groundwork lacquer (*shitamakiye*) is applied, two or three times or more, till the required height is attained. The shape and figures of the various substances are worked out at this stage. It is finished with a coat of any desired colour, usually gold, silver, green or red lacquer, and then ground and polished in the usual way.

The various powders employed in ornamenting the lacquered wares in the way above mentioned are gold, silver, and tin of various degrees of purity and fineness of division. The finest powder of either gold or silver is prepared from its leaves by the aid of glue, and is called the *keshiko;* the *uashijí*, and *hirame*, produced from the filings of the metals, are much coarser grained. That portion of the filings which passes through a fine sieve constitutes the *uashiji* powder, and the residue remaining upon the sieve, after being well rubbed and pressed, gives the *hirame* powder. The other preparations of the powders are *benigara*, red oxide of iron; *jonōko*, a burnt porcelain clay; *hikikō*, a fine whetstone powder; powdered and calcined deer's horn and charcoal, most of which are applied in the form of paste. *Sabikō* is a mixture of equal parts of *jonōko* and lacquer juice, and is used for making the groundwork of raised lacquer ware.

6. *Tsugaru Nuri and Wakasa Nuri.*—These styles of lacquered wares are manufactured in the districts of Tsugaru (Province of Mutsu) and Wakasa. The first stage of applying the lacquer is the same as in *roiro*, or in red lacquering. In *Tsugaru* ware the finishing coat consists of a layer of green lacquer, over which small quantities of yellow and brown lacquers are distributed in irregular spots and lines, so that the

whole surface presents a cloudy appearance. It is finally ground, and polished with deer's horn powder and oil. *Wakasa nuri* is very like *Tsugaru nuri* in its general features, containing, however, besides the above, an ornamentation with gold and silver leaves, either irregularly distributed in spots, or in the form of floral and landscape designs. To make this, the surface of the ware, after receiving the priming and middle coats of lacquer, is covered with a layer of a yellowish lacquer, over which the impressions of the intended design are made by pressing. After being dried the leaves of the metals are applied over the whole surface of the ware; another coat of lacquer is given, and when dry it is ground down till the pattern stands out. It is then finished with a thin coat of transparent lacquer. Some kinds of *Wakasa* ware are inlaid with small shells, others exhibit an appearance of the *moiré metallique* of French tin-plate.

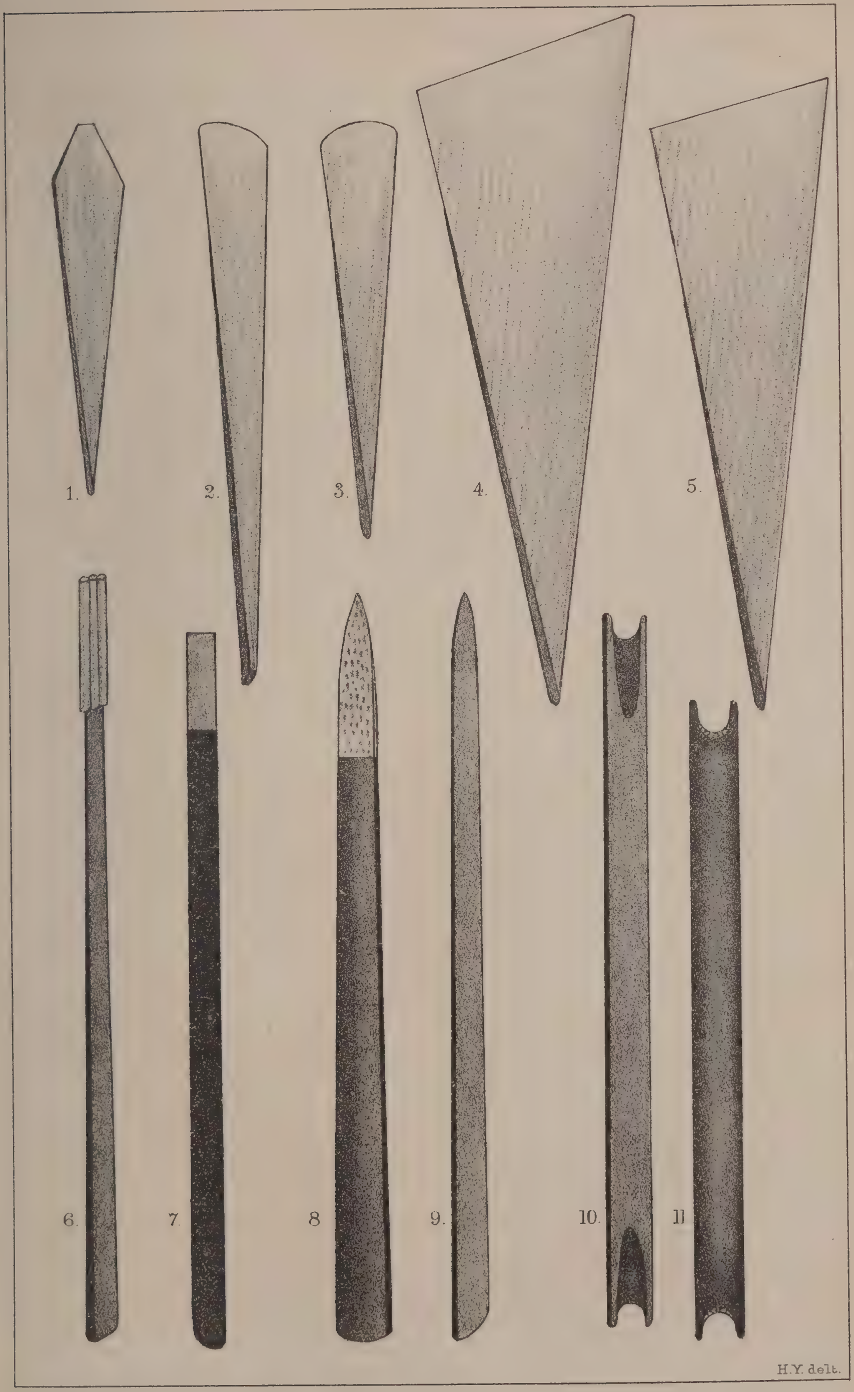
Besides these principal styles and processes of lacquering, there are some in which these various styles are combined in a single ware. Other wares are ornamented by inlaying plates of gold, silver, porcelain, and mother-of-pearl, or by engravings of various designs.

The instruments employed in lacquering are:—

1. Triangular spatulas of various sizes used for mixing and compounding the various ingredients. (Plate IX. figs. 1 to 5.)
2. Thin bamboo and whalebone spatulas, with tapering and curved ends, used in laying the lacquer in a special part of the ware where elevation or depression is required. (Plate IX. figs. 6 to 11.)
3. A number of small brushes made from the hairs of men, horses, hares, or cats, for distributing the lacquer (Plate X. figs. 5 to 9), and also for the various powders (Plate X. figs. 2 to 4).
4. Bamboo tubings with perforations of different fineness, for spreading metallic powders in *uashiji*-making. (Plate X. fig. 1.)
5. Quills and soft feathers of various sizes, for distributing and removing the excess of gold and silver powders.
6. Number of palette-boards and knife.

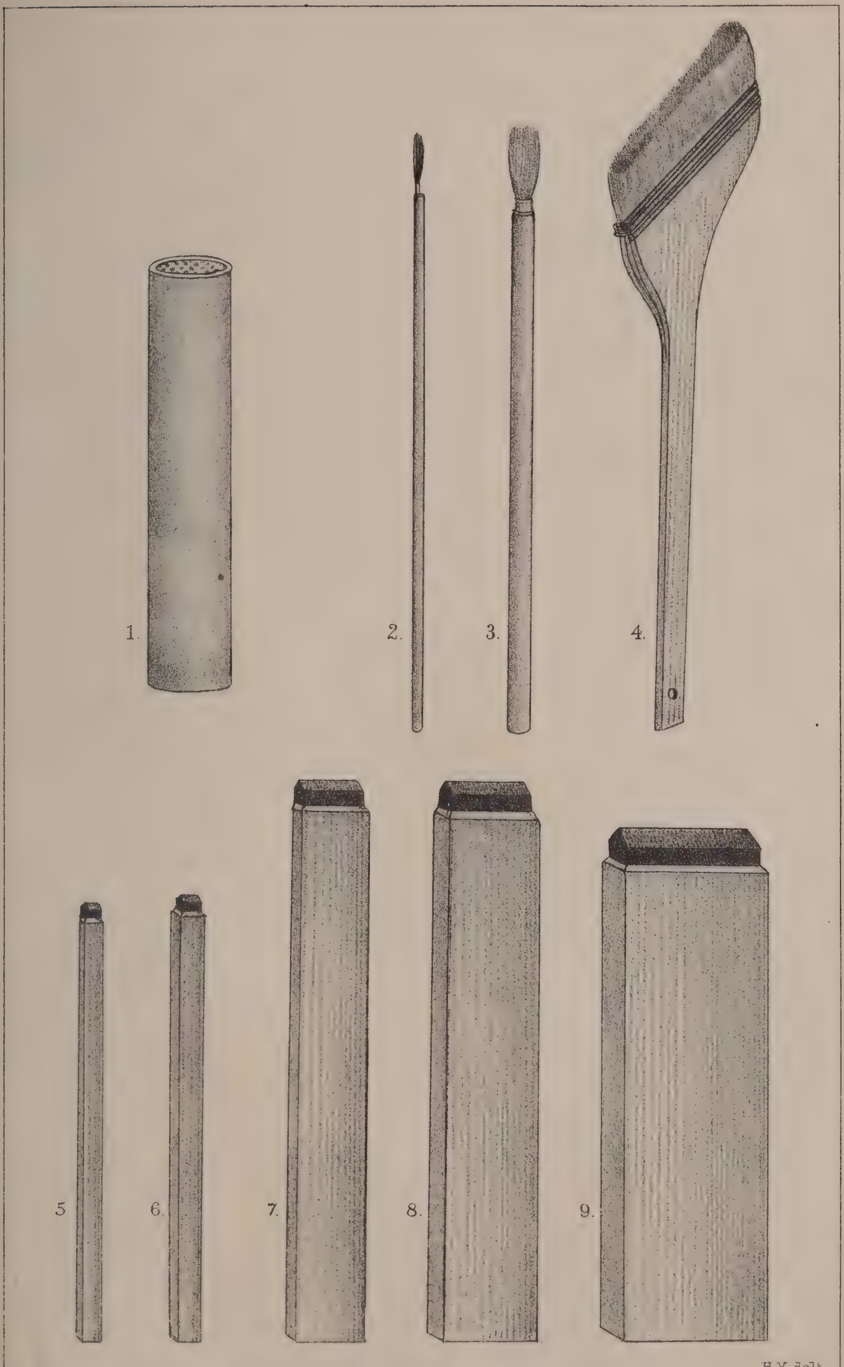
The choice in the quality of the woods for making the

Pl. IX.



Instruments used in Lacquering.

Pl. X.



Instruments used in Lacquering.

lacquer wares, as Mr. J. J. Quin remarks, naturally depends upon the use to which it is intended to be put. Those used for cabinets and such small articles of the first class are as follows:—

1. *Paulownia imperialis* (*Kiri*); fine-grained is the best.
2. *Magnolia hypoleuca* (*Honoki*).
3. *Chamœcypanis obtusa* (*Hinoki*).
4. *Abies tsuga* (*Tsuganoki*), a species of fir.
5. *Himekomatsu*, another species of fir, is considered the best for making carvings, and for engraving.
6. *Cryptomeria Japonica* (*Sugi*),
7. *Planera Japonica* (*Keyaki*), } extensively used for common lacquered furnitures.
8. *Prunus pseudo-cerasus* (*Sakura*),
9. *Gingko biloba* (*Ishio*),
10. *Cercidiphyllum Japonicum* (*Katsura*), } also used to some extent.

In closing this essay on Lacquer, I have to express my great indebtedness to several of my friends—Messrs. Magaribuchi, O. Horschelt, J. Sakura, J. Takayama, and J. Matsumura, without whose kind assistance it would have been very imperfect. I have also to return my best thanks to the authors of the various papers on Lacquer which I have consulted, and which have been very serviceable to me; especially I thank Messrs. J. J. Quin,[1] N. Oshikawa, and Komiya,[2] and S. Hiraga.[3]

This essay was accompanied by numerous specimens of lacquers and lacquered ware.

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[1] *The Lacquer Industry of Japan*, by J. J. Quin.

[2] *Reuno Kai Shi*, vol. iii., by Oshikawa and Komiya.

[3] *Japanese Lacquer*, by S. Hiraga (formerly Mr. Ishimatsu).

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N.B.—*Specific names of animals and plants and the titles of books referred to are printed in italics.*

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